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Auctions as a measure in meeting renewable energy targets: Selected cases from developing countries

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With the determination to achieve 100% carbon free energy generation by 2050, renewable energy has been widely accepted as a feasible option for environmentally friendly and inclusive economic growth. Giving priority to this support mechanism is vital to upholding a steady and conducive atmosphere for investment in this sector while meeting the anticipated target in the energy system in an economical way, and policy makers reveal that auctions have reached their pinnacle in due course of time. Merely 29 states had applied renewable energy auctions up to the end of 2017 and their number increased to 41 in 2019. The present study aims to prepare a roadmap for achieving the carbon free green energy production target within the stipulated period while meeting future energy demand through a cost-effective auctioning scheme. The research outlines the feasibility of suggested auctioning schemes, highlighting some country-specific empirical evidence and potential benefits for countries. For this, qualitative research has been conducted to summarize and assess the necessary conditions to develop an auctioning model. The results indicate that for the emerging economics that are provided with renewable energy sources, technology-neutral site-specific volume auctions systematically scheduled, together with socio-economic development instruments under qualification requirement, result in diversified gains.

Keywords: renewable energy, auction scheme, cost-effectiveness, socio-economic development, diversified gains

1. Introduction

The adverse effects of environmental degradation are now of concern in all walks of life and in the mean-time, entire nations - irrespective of developed or developing - have started making diverse and extensive efforts to adopt new measures to mitigate the effects. For the socio-economic upliftment of developing countries, the importance of availing themselves to sustainable and environmentally responsible sources of energy has been engrained as a precondition. Fossil fuels have for long been burnt in earlier eras to generate electricity, and are responsible for the emission of huge amounts of carbon dioxide (CO_2) into the air. Thus, the majority of the world's leading policy makers are determined to reach 100% carbon free energy generation by 2050. Highlighting this determination, the extensive deployment and utilization of renewable energy (RE) has gained high priority in the related policies on sustainability and climate change in the global arena.

Apprehension in the world community to the spectacle of detrimental climate change (i.e., global warming due to carbon emission) has led to investment in/support research in RE with affordable, economical, and technologically developed means. According to the Sustainable Development Goal (SDG) 7, it is urged that "Clean Energy for everyone"- secure access to affordable, reliable, sustainable, and modern energy for

everyone. To make RE affordable and economical, the cost must be competitive and not put further burden especially on developing countries. If RE prices become competitive, RE will become affordable to wider society. To this end, current practices are showing that an auction scheme for renewable energy sources (RES) can be a fruitful medium for delivering affordable energy in both developed and developing countries.

Bangladesh has achieved steady economic growth for the last decade. Very recently (27 February 2021), Bangladesh received the second recommendation from World Bank to be removed from the list of least developed countries (LDC) and step up into the list of developing countries. As per the projection of Japan International Cooperative Agency (JICA), the gross domestic product (GDP) per capita (nominal) for Bangladesh is expected to reach 10,993 US$ in 2041 and Bangladesh has set the goal of being a developed nation by 2041 (source: PSMP 2016). Further, PSMP (2016) says, by 2041 Bangladesh's power generation target will be 60,000 MW, of which 10%, i.e., 6,000 MW will be from RES.

In keeping industrial production steady, electricity plays a crucial role. Most electricity in Bangladesh is produced by gas (57.36%), alongside 25.16% by furnish oil (HFO), and 7.23% by high-speed diesel (HSD) (source: Power Cell, Bangladesh on June 2020). But due to the gradual declination of indigenous gas reserves and the limitation in new gas wells, Bangladesh is also importing liquefied natural gas (LNG). Recent analysis shows that the energy import cost for Bangladesh will be 20,000 million US$ in 2030. But the country has the potential to acquire electricity from solar (mostly) and wind. According to National Renewable Energy Laboratory (NREL), the country experiences wind speed of 5.75–7.75 ms^{-1} and there are more than 20,000 m^2 of land with a gross wind potential of over 30,000 megawatts (MW). NREL also says that Bangladesh receives moderate level solar radiation on a daily basis (GHI≈ 4.5 kWh/m^2) which can be converted into reasonable sources of energy via either a thermal or PV route. By 2020, the electricity production from RE was 650 MW (source: Power Cell, Bangladesh), which was far beyond the expected level.

Aligning itself with the world's carbon reduction target, Bangladesh ratified the Paris Agreement on 21 September 2016. On 25 September 2015, it submitted Intended Nationally Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) with an ambitious Green House Gas (GHG) reduction target of 15%, i.e., 36 $MtCO_2$ conditional and 5%, i.e., 12 $MtCO_2$ unconditional from Business as Usual (BAU) by 2030 (source: INDC 2020). But in reality, the CO_2 emissions trend from fuel combustion in Bangladesh is upward – in 2014 it was 63.10 $MtCO_2$ and 82.00 $MtCO_2$ in 2018 (source: IEA world Atlas 2018).

Recently, Bangladesh drafted its 'National Solar Energy Roadmap 2021-2041' for achieving its RE target by 2041 considering 03 scenarios-BAU, medium case & high case and based on these scenarios the potentiality of GHG emission reduction has been calculated as well matching with the global performance. But in considering all of these aspects, as a developing and emerging country and one of the states most susceptible to climate change, Bangladesh is worthy of mention over the last decade.

Any state like Bangladesh struggles with a complex issue like climate change, meeting an RE target for securing reliable energy at an affordable cost and ensuring economic growth despite abandoning the comfortable track on which everything will

arise in time. Due to climate change and the energy security issue, the world is eager to exploit RE for producing green energy by following the competitive auctioning scheme.

There are two main arguments often identified as driving the use of RES auctions: Firstly, they allow an efficient allocation of support at a level that is competitively determined and reflects realistic cost for the selected projects at the time when they are implemented. Secondly, they allow for non-discriminatory and competitive volume control of RES deployment (i.e., avoiding first come-first-served schemes) and thus control of total support budgets. Both of these can be attractive to policy-makers faced with growing support commitments that burden consumers/taxpayers (Kitzing et al. 2019). But the empirical evidence proves the advantages of an auction scheme which overcome these arguments in many aspects.

Lower prices are the prime motivation for the espousal of auction schemes globally. In the last decade the prices of solar and wind auction have lessened a lot. In 2010, the global average contracted price for solar energy was around 250 USD/MWh which came at 56 USD/MWh in 2018, i.e., a 78% price reduction in 8 years (IRENA 2019). Similarly, the wind price fell as well; but compared to solar, the reduction was slower than solar. The weighted average price of wind in 2018 was 50 USD/MWh, dropping from 75 USD/MWh in 2010, i.e., a 33% price reduction in 8 years (IRENA 2019).

On the other hand, the reduction of technology cost in the interim led global RE experts and decision makers to accept the auction scheme more robustly as a medium of shaping the market price of renewables in their framework, circumventing windfall earnings for the inventors. For example, a notable price decline occurred for onshore wind in Brazil from USD 28.96/MWh in December 2017 to USD 18.58/MWh in April 2018. For solar PV, 17 GW capacity was solely owed by India at an average price 42.3 USD/MWh, and the Philippines for a 50 MW capacity received bids at a low cost of 43.9 USD/MWh (IRENA 2019).

But still, power projects (both conventional & RE) are awarded on an unsolicited basis (Power Purchase Agreement -PPA/Request for Quotation-RFQ) and tariffs are determined through direct negotiation (between BPDB & Independent Power Producer-IPP) in Bangladesh; and in this regard, the RE price is high compared to global trends. This is the moment where auction schemes should be investigated, since suitable and tailored auction schemes can be a solution to achieve reliable green energy at an affordable cost. So, this research will be a roadmap for achieving the carbon free green energy generation target within the stipulated period for meeting the future with safe and secure energy through a cost-effective auctioning scheme with diverse paybacks.

2. Literature Review

When the auctions are structured analyzing any country's economic, political, and RE goals; only then can it yield positive consequences. The experience gained from different countries may be a guideline for new entrants into the auction world. This section is underlined with theoretical aspects along with some country-specific empirical evidence together with with auction design features.

The 'auction' was first described academically by Columbia University's Professor William Vickrey in 1961 though it had been used by stamp collectors as early

as 1893. In a Vickrey auction, bidders are unaware of the bids of other individuals. The winner of the bid does not pay the winning bid price - they pay the second-highest bid price. In such an auction, individuals are encouraged to bid their maximum willingness to pay. The use of auctions for advancing renewable energy capacity is not a new concept. It was started in 1990s by UK's Non-fossil Fuel Obligation (NFFO) and achieved mixed results at best.

An auction is a selection process designed to procure (or allocate) goods and services competitively, where the allocation is awarded based on financial offers from pre-qualified bidders. When competition is feasible and desirable, auctions have proven to be a very effective mechanism for attracting new players and efficiently matching supply and demand, and they have played a major role in several economic sectors. An auction also increases the transparency of the procurement process, making the resulting obligations less likely to be challenged in the future as the political and institutional landscapes change (World Bank Group 2014). Auctioning plays a remarkable role in various economic sectors, besides the auction process itself being transparent and well accepted by all.

Renewable energy auctions are also known as "demand auctions" or "procurement auctions", in which the government issues a call for tenders to procure a certain capacity or generation of renewables-based electricity. Project developers who participate in the auction typically submit a bid with a price per unit of electricity at which they are able to realize the project. The auctioneer evaluates the offers on the basis of the price and other criteria and signs a power purchase agreement with the successful bidder (IRENA 2015). So, the selection of the winner is solely based on the bid price. "Argentina's RE auction experience to date has demonstrated that RE projects are cost effective against traditional power generation options in that country" (AURES II D2.1-AR 2019, 22).

Auctions provide governments with a market-based framework and an efficient allocation tool to meet policy objectives such as renewable deployment, tariff reduction, reliability improvements, carbon emissions control, economic development, and increased foreign investment. While a variety of policies exist to promote the development of renewable energy, competitive auctions have emerged as a preferred policy for utility-scale renewable energy development. Auctions can be designed to result in procurement of a specific quantity of electricity (or capacity to be built) at a strike price. Renewable procurement schemes can also be designed with a fixed budget, allowing quantity to be determined by the market (Hochberg and Poudineh 2018).

The features of cost-effectiveness, enabling real price discovery in terms of the project and resulting lower support level, mean many countries of the world are shifting to feed-in tariff to competitive auction process (Kreiss et al. 2017). So, the study proposes that the auction mechanism for RE is offering competitive price, faster project execution, easier to scale up for multiple projects and rounds, and thus it attracts multiple bidders.

Auctions are extremely flexible allocation mechanisms, allowing policy-makers to specify when to call for a certain amount of new RES deployment, what technologies are to be supported, which type of support they receive and when projects should be delivered. As with other RES support schemes, the success of auctions

depends on the design elements chosen and how well they address specific characteristics of the technologies and markets (Shrimali et al. 2016).

Auction design is an important concern for policy-makers as because without assessing the real requirements of any country's RE, socio-economic and political goals, auction cannot produce satisfactory outcomes. A lot of studies explain that the auction purpose has not be fulfilled due to lack of inadequate prequalification, technology specificity, pricing rule, auction schedule, auction type, price allocation process, unclear specified penalties, or complex auctioning practice (Kreiss et al. 2017, Kitzing et al. 2019, Rio-Linares 2014, Gephart et. al. 2017, Bayer et al. 2018, Shrimali et al. 2016). As per the report, in 2005 about 6 countries implemented auction/tender system for capacity procurement and in 2018, this number rising to 84 (REN21 2018). The report says that at least 29 states applied RE auction schemes in 2017 and the number is being increased to 41 in 2019 (USAID 2019). So, the competitive auction scheme is catching the attention of the world's policy leaders and gradually its adaption is increasing worldwide.

2.1. Auction features and gains: some empirical evidences

2.1.1. Volume auction

The volume auction refers to the amount of renewable electricity demanded by the auctioneer in each individual auction and the key input to the auction is to impact the expected volume of RE. Auction volume can be defined in terms of capacity (MW), generation (MWh), or budget (million EURO/USD). So far capacity caps have been the most common (Kitzing et al. 2019). A high auction volume may induce additional actors to partake and thus upsurge competition, and accomplish lower prices (Schmidt et al. 2019). "Many believe that because attractiveness for developers, is strong, larger amounts of electricity should be auctioned" (AURES II D2.2-HU 2020, p. 20). According to IRENA (2015), for experiencing wild energy growth and speedy capacity adding in any economy, volume auction is highly acceptable. But target setting must be collaborated with government policies for RE deployment and technical capabilities of existing system to absorb the RE. There are three ways to determine the auction volume: (1) under a fixed volume method; (2) in a price-sensitive demand curve mechanism; and (3) in a multi-criteria volume setting method. Among these three ways, the first one has been the most common option implemented worldwide, and seems to be reasonably functional. Fixed volume approach is beneficial for its simplicity, transparency, and offering guidelines to the bidders. Further, governments can accommodate a limited budget for the support of renewables by implementing a price cap mechanism by this approach.

Relating to this approach, one case of South Africa in 2011 is instructive. For the first round of the auction was not so successful in enhancing a competitive point of view. The first round consisted of a total five rounds for a capacity target of 3727 MW. In different demand bands of the first round, the volume of the auction was not defined. But the second round was successful, as it led to higher participation of bidders and a reduction of price and it was made due to a set volume cap (IRENA 2015).

2.1.2. Regular/systematic auctioning schedule

Systematic auctioning scheme involves a commitment to a longer-term auctioning schedule. This scheme allows market agents to better adjust their expectations and to plan for the longer term. Additionally, introducing a steady stream of new projects rather than a substantial, aperiodic influx (as is typically the case with stand-alone auctions) helps the government to promote the development of a local industry. In addition, having a long-term auction schedule provides better guidance for planning the grid infrastructure, so that the stream of new projects is smoothly integrated. Choosing this option, however, may result in a risk of overcommitment, forcing the government to dynamically adjust the auction schedule and quantities according to perceived shifts in market conditions (IRENA 2015).

Systematic auction schedule decreases risk & increases investors' confidence, reduces bid prices, encourages technological progress and thus reduces technology prices, prevents underbidding as bidders do not need to bid aggressively in a given round to secure a contact, allows potential investors to enter into the market, and follows a learning by doing process (IRENA 2016, Gonzalez 2017, Hochberg–Poudineh 2018, IRENA and CEM 2015, Mora et al. 2017, Wigand et al. 2016).

The National Solar Mission in India aimed to support the development of the solar power sector and committed to a systematic auctioning scheme. Between the first and second round, the total capacity offered in the bids increased by 100%, the percentage of projects installed in a timely manner increased from 89% to 100%, and the price dropped by 28%. In California, four auctions were planned from the get-go, to be carried out in the timespan of two years, with predetermined demand levels (although those quantities were later revised upwards). In Germany, one of the main features of the newly designed auction is the longer-term planning and a pre-commitment to a schedule. Nine auctions were planned over the course of 2015–2017. The reason for having a systematic auctioning scheme is to ensure a continuous renewable energy project pipeline, while at the same time to test different design elements in different auction rounds (IRENA 2015, IRENA 2017).

2.1.3. Technology-neutrality of auction

Technology-neutral RE auctions are competitive bidding processes without any formal restrictions on the participation of available technologies, in which neither negative nor positive technology-specific discriminatory rules exist. This design (1) minimizes generation cost; (2) ensures compliance with applicable regulation demand-no technology discrimination; and (3) encourages more actors to participate as more technologies are included. Finally, if the aim of auction is to minimize costs, a technology-neutral auction can be initiated, allowing competition between technologies, therefore favoring the more mature and cost-competitive one (Gonzalez 2017, IRENA and CEM 2015, GIZ 2015, Wigand et al. 2016, Mora et al. 2017, Roy et al. 2016, Mora et al. 2017 (D9.2)).

As per USAID auction toolkit (2020), a recent example of this type of auction, which uses bidding on premiums to renewable generators selling into the wholesale electricity market, is the successful technology-neutral auction held in Finland in 2019. In this auction, 1.36 TWh of energy was contracted at an average premium of €2.51

(2.95 USD) per TWh. "In 2017, Chile introduced technology-neutral auctions that included both conventional and RE plants. Bidders bid into hourly and seasonal time blocks, reflecting different power system needs. This design enabled RE projects to win 100% of the offered capacity" (USAID 2019, p. 15).

2.1.4. Site-specificity of auction

In site-specific auction, the government selects the project site and pre-develops the site either partially or fully. Here government defines a target volume for the auction round and bidders then compete for the right to construct their projects at the specific site. This type of auction allows for better coordination between project construction and required grid expansion. Site-specific auctions reduce the risks and costs associated with the project development process for bidders. But faulty pre-development work would reduce this benefit. In Zambia's first auction round, site selection issues on the project sites led to additional development work after project award. (USAID 2019).

Site-specific auction has probably reduced risk and transition costs for producers which was reflected in the lower price level. Further, auction was organized in specific areas with very good RES and after an extended time without a scheme, demand was higher. A Portuguese 1400 MW capacity auction was implemented in this way (AURES II D2.1-PT 2019).

2.1.5. Pay-as-bid pricing rule for auction

In the arena of RE auction, pay-as-bid pricing mechanism is the most common approach. By pay-as-bid pricing rule, auction bidders pay their reported demand for each unit they obtain and winners are awarded the remuneration for which they bid (Haelg 2020).

Pay-as-bid implementations are typically seen as a means to minimize costs, offering bidders no more than their bid, which is supposed to be the minimum required for developing the renewable energy project. This gives these schemes much wider appeal from a social and political standpoint. The cost-effectiveness of the auction mechanism tends to be an important driver behind the widespread adoption of pay-as-bid pricing (IRENA 2015). Pay-as-bid pricing may favor more financially viable projects with a higher likelihood of on-time implementation (Shrimali et al. 2016). Renewable energy projects implemented by Argentina, Hungary, Mexico, Portugal, Ukraine have followed a pay-as-bid pricing rule in auction features (AURES II 2019, AURES II 2020).

2.1.6. Ceiling price allocation process for auction

A ceiling price acts to avoid excessive producer's revenue when there is little or limited competition in the auction. Disclosing the ceiling price to bidders in advance prevents otherwise qualifying projects from being rejected simply because bidders did not know the ceiling price. The disclosure of the ceiling price also gives bidders more planning security (USAID 2019). The ceiling price allocation process can prevent excessive prices and may prevent collusion and price manipulation. High ceiling prices attract more participants, though potentially weaker ones. This process can help government to acknowledge up front that there is a risk whether the auction scheme may fulfill its

intended role (achieve low cost) or not (Gonzalez 2017, IRENA and CEM 2015, Gephart 2017). So, a ceiling price is a maximum price above which bids will be disqualified.

The auctioneer needs to decide whether the ceiling price should be disclosed prior to the auction. Full disclosure tends to involve a slightly greater degree of transparency, but in the case of limited competition may result in bids that are just below the ceiling price. Leaving the ceiling price undisclosed can result in disqualification of otherwise sound bids that are only slightly higher than the ceiling price. By introducing a ceiling price, there is an upfront acknowledgement of a risk that the auction scheme may not fulfil its intended role of achieving low prices and that, as a result, the auctioned volume will not be fully contracted. In South Africa, the disclosure of the ceiling price combined with the lack of a strict volume cap resulted in high prices. The subsequent rounds, with undisclosed ceiling prices and well-defined volume caps, led to significantly lower prices. The intense competition in the Indian auction meant that the "anchoring" caused by the disclosed price caps was of little concern (IRENA 2015).

2.1.7. Hybrid auctioning type

Hybrid type auction defines an auction where the first phase follows as a descending clock auction and in the second phase operates as a pay-as-bid sealed-bid auction. The aim of the hybrid auction is to take the benefit of price discovery via descending clock auction and to avoid collusion between small quantities of participants for fixing the final price via seal-bid auction (IRENA 2013). This type of auction may allow for real price discovery (ceiling price) in a dynamic auction and prevent collusion thanks to a subsequent seal-bid auction (Gonzalez 2017). Hybrid auction may be little bit complex; but real price detection and conspiracy prevention are possible here.

Brazil, in its auction process, has combined a descending-clock auction followed by a pay-as-bid round. The auctioneer positively decreases prices, collecting investor's quantity bids, until a point when overall supply is greater than demand by a certain factor, unknown to the bidders. After this, a sealed-bid auction takes place (IRENA 2015).

2.1.8. RE-plus-storage

To help utilities, grid operators, and customers with better integrated distributed RE generation by maintaining grid stability and reliability, RE-plus-storage is another increasingly popular strategy to address the timing of energy output. To enhance dispatchability and to improve value of energy, many countries around the world are using this RE-plus-storage.

For example, in December 2019, the Solar Energy Corporation of India (SECI) held an auction for 1.2 gigawatts (GW) of dispatchable RE-plus-storage capacity. The plants must be available during peak hours, which are specified by SECI as 5:30 to 9:30 a.m. and 5:30 p.m. to 12:30 a.m. daily (USAID RE Auction Toolkit 2020). As per National Solar Energy Federation of India (NSEFI) of May 2020, the recently concluded 400 MW renewables auction to supply 24-hour electricity saw a winning bid of INR 2.90/kWh (0.04 USD/kWh) – a new milestone after peak & off-peak tariff on INR 4.07/kWh (0.055 USD/kWh) was achieved in December 2019's 1.2 GW auction seeking assured power supply during peak-demand hour (NSEFI news portal).

2.1.9. Qualification requirement in auction design as a socio-economic development instrument

Qualification requirements to promote socio-economic development will be aimed at local industry development or local empowerment and employment. The qualification requirements can be a means to ensure that the bidders have the financial, technical, and legal capability to develop the project. In line with the country's overall objectives, policy makers can introduce design elements to maximize socio-economic benefits from renewable energy deployment. Usually, these goals are reached either by imposing qualification requirements or by introducing a criterion in the winner selection process (IRENA 2015). Auctions can also include local content requirements/socio-economic development requirement to ensure the development of industries, creation of jobs, local industrial development in the renewable energy sector (IRENA 2013). Qualification requirements and/or penalties are useful auction design elements to increase the implementation rates of selected projects (Gephart et al. 2017). Hence, the qualification requirement with socio-economic development instrument can ensure diverse paybacks to the country.

For instance, projects awarded in Morocco have been reporting the benefits achieved due to inclusion of socio-economic development goals as qualification requirement. Morocco's 'Noor-Ouarzazate' RE project consisted of four phases. Noor I phase indeed sourced 30–35% of the project cost in local components and services. Throughout the four phases, 70% i.e., 6,430 Moroccans were employed and a third of the jobs were sourced locally from the region of Ouarzazate. Again, South Africa's 'Renewable Energy Independent Power Producer Procurement Program (REIPPPP) consisted of a total of seven rounds that attracted 14.64 billion USD by March 2019. When it comes to local content, 3.27 billion USD were spent locally out of total spending of 90.3 billion USD. In terms of job creation, the REIPPPP has created a total of 40,134 job-years for South African citizens. The procurement was surpassed with local equity shareholding across all arounds reaching 52%. The REIPPPP contributes to Broad Based Black Economic Empowerment (BBBEE) and the creation of Black industrialists and Black South Africans means own on average 33% of the projects (IRENA 2019).

3. Methodology

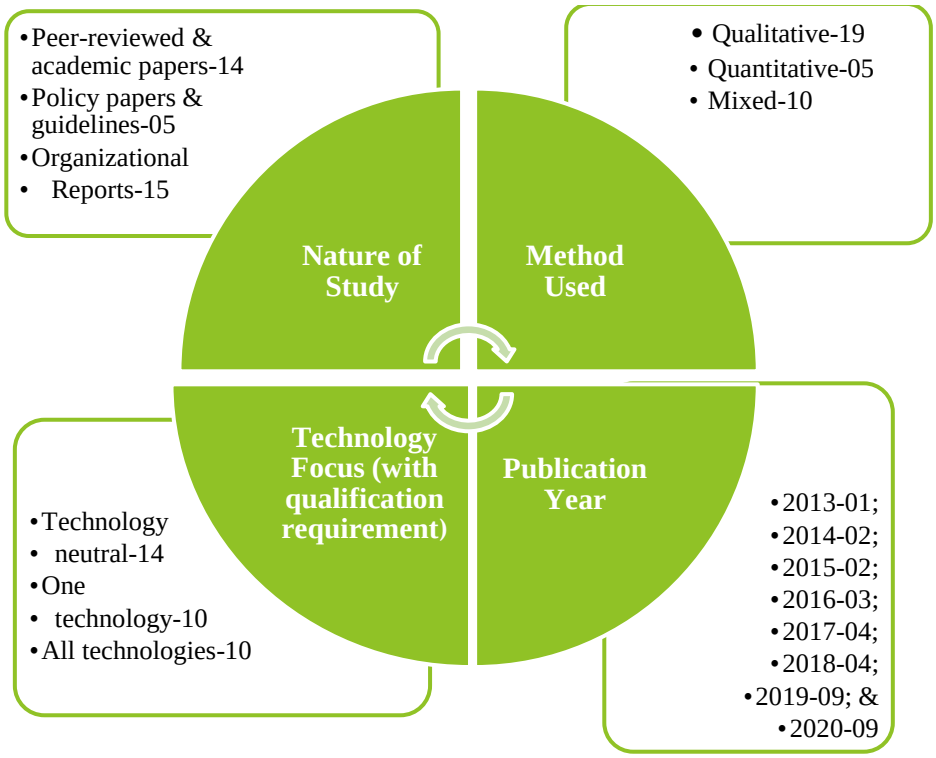
The research is mainly qualitative in nature. For the qualitative part, i.e., for probing the suitable auction design process, it has been piloted on the basis of a systematic literature review focusing on three aims: first, to find out the potentiality of auction; second, to identify the design features of the auction, and third, to find out the gains of the auction following some country-specific empirical evidence.

For examining how auctions are used in relation to cost-effective renewable energy deployment, a systematic literature review that comprised a reproducible search and applied explicit criteria for the inclusion and exclusion of studies was conducted (Sovacool et al. 2018). A semi structured approach was used based on Petticrew and Roberts (2006).

In the abstract database Scopus, peer-reviewed literature assembled via a keyword search and 'renewable energy auction design' was identified. In the next phase, a snowball sampling round was conducted for the cited articles in the preliminary phase (Cooper 1998). Further, some country-specific policy reports, guidelines, organizational reports, and policy papers have been added here as those have helped to give feedback about the literature of auction design and paybacks amounting to a list of articles from 54 studies.

Out of these studies, highlighting a link between auction design, gains, and country-specific evidence, the list was narrowed down to 34 studies summarized in figure 1 which presents them according to the nature of study, its technology focus, its year of publication, and usage of method. Most of the studies were qualitative in nature.

Figure 1 Compressed qualitative summery



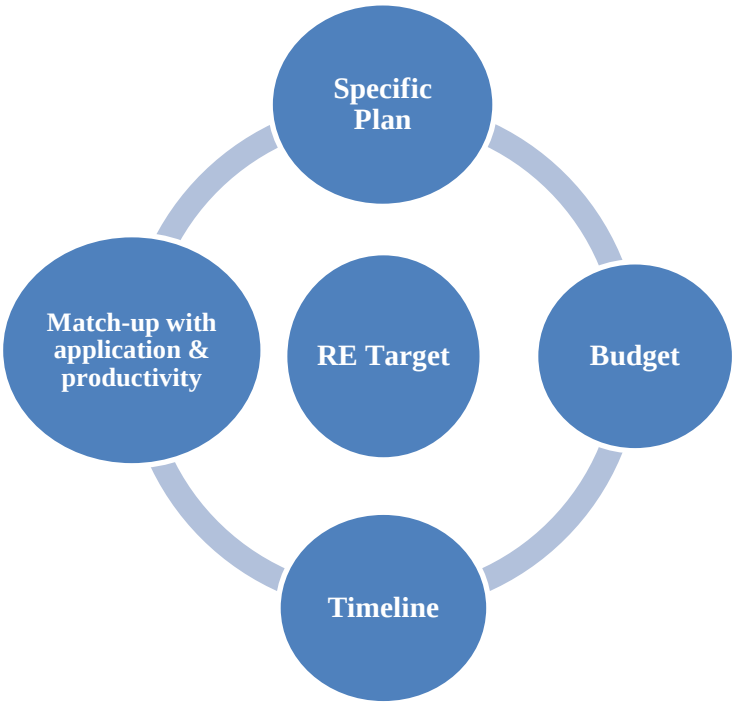
Source: own construction based on the characteristics of articles

Based on the 34 studies, a list was compiled concentrating on the features of auction design, auction pricing rule, technology specificity, location specificity, auction volume, and the outcomes of the auction. Specially, how an auction design feature with systematic scheduling mixed with socio-economic development instrument under qualification requirement resulting in diversified gains was searched for by the qualitative screening of the studies.

4. Results

Like many countries, Bangladesh is one of the world's speedily growing developing economies aiming to face the vulnerability to climate change by keeping its progress phase steady. Focusing on these two decisive aspects necessitates the insertion of sustainable and renewable energy sources into the country's long-term growth target. A clear-cut vision supported by structured strategies are indispensable for the development of any sector, and renewable energy is not far beyond of that. For meeting the RE target, any country needs a mingling of specific plan, budget, timeline, and match-up with application & productivity (see Figure 2).

Figure 2 Requirements for meeting RE target



Source: Own construction based of discussion

In meeting the high volume RE target (see Table 2) by stipulated period for gaining 100% carbon free energy generation, auction will be an effective measure. The result of the literature review (see Table 1) suggests that only a decent handful of auction design features can directly and indirectly ensure diverse paybacks.

Table 1 Summary of the literature review

Auction Feature	Paybacks/gains
Auction/demand auction/competitive bidding	Ensure transparency in energy procurement process; offer competitive price; help to deployment of targeted amount of RE within fixed budget; offer faster project execution, reduce windfall profits for power producers; scales up multiple projects and attracts multiple bidders
Volume Auction	Support for high energy growth & speedy capacity adding; attract more bidders; upsurge competition; accomplish lower price
Regular/systematic auctioning schedule	Promote the development of local industry; better guidance for placing the grid infrastructure; decrease risk & increase investor confidence; reduce bid price; encourage technological progress thus reduce technology prices; prevent underbidding as other projects are in the pipeline; learning by doing process
Technology-neutrality of auction	Minimize generation cost; ensure compliance with applicable regulation demand; encourage more actors to participate for inclusion of more technology
Site-specificity of auction	Bangladesh has land scarcity. For ensuring grid connectivity of RE, this feature is effective. This feature encourages participation & competition; ensures lower participation cost & risk; attract new market entrants; achieve geographical diversity
Pay-as-bid pricing rule	Minimize cost of RE; actual discover of real demanded price; favor more financially viable projects
Ceiling price allocation process	Prevent excessive price, collusion & price manipulation; attract more participants even potentially weaker one; help government to acknowledge upfront that there is a risk whether the auction scheme may fulfill its intended role or not
Hybrid type auction	Provide benefit of price discovery; prevent collusion between small quantity of participants for fixing the final price
RE-plus storage	Recently developed auction strategy that improves the value of energy; enhance dispatchability; and help utility, grid operators & customers with better integrated distributed RE generation by maintaining grid stability & reliability
Qualification requirement in auction design as socio-economic development instrument	Ensure local industrial development; gear up local empowerment; create new employment generation; facilitate regional economic development

Source: Author's own creation based on literature review

It is vital for any developing country like Bangladesh to prepare for the near future when the stock of the non-renewable fossil fuels will be on the verge of depletion globally and environmental mishaps will pose an added menace for livelihoods. Due to the increase of the efficiency of technology, the coming future will surely see the reduced price of RE. The universal picture is robustly updating, and the share of RE in the energy-mix is enhancing day by day. This highlights the philosophy of sustainable and affordable

uninterrupted quality energy for everyone by 2021, Bangladesh has introduced some measures (specially for RE expansion) lining up with global actions (we can call those 'with existing measures-WEM'), such as:

- Large-scale grid tied solar PV projects (3 MW-200 MW capacity)
- Solar home system (SHS)
- Solar mini grid (SMG)
- Solar irrigation pump (SIP)
- Net energy metering for rooftop solar PV system
- Solar drinking water
- Solar power telecom tower
- Solar street light
- Solar charging station

In that any emerging economy like Bangladesh which is provided with renewable energy sources and which does not yet follow auction process, technology-neutral site-specific volume auction systematically scheduled combined with socio-economic development instruments under qualification requirement can make it beneficial by confirming diversified gains through practicing the features mentioned.

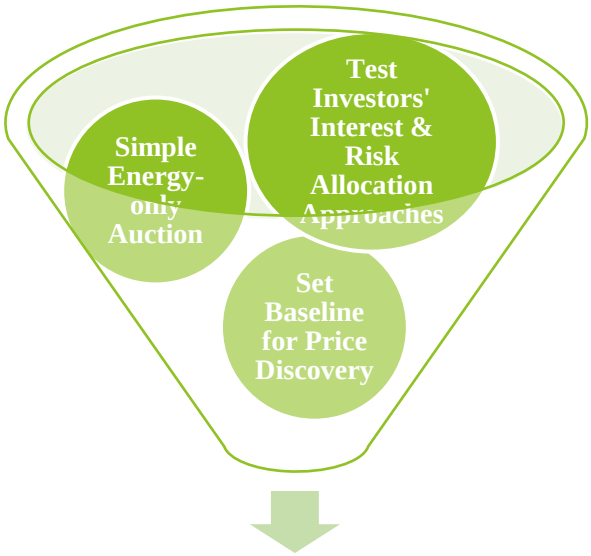
5. Conclusion and future policy implications

Over the last decade, auction schemes have been used as a RE-support and the sharing of grid connection capabilities have been an operative feature. RE-plus-storage is a new dimension in this arena. Renewable energy sources have become economically competitive with fossil fuels in many jurisdictions while being a totally environment friendly and supportive tool to reduce GHG emission further. In coming years, RE will become cheaper than any fossil fuel-based energy by following an auctioning mechanism. Cheaper power from RE sources will be the chief driving force in the energy industry. After robust initiation of RE, the backward and forward linkages will expand, no doubt. India is good example of this claim. Systematic auction scheme will keep RE projects in the pipeline.

In this paper, the analysis of various literature findings on some auction design features and their returns on auction consequences may also assist policymakers in estimating probable paybacks of their design choices for early-auction and thus valuate trade-offs among different auction designs and qualification requirements.

Gaining the proposed goals (see Table 2), auction should be introduced in unsolicited form for awarding projects in the power sector. The first auction does not have any complex feature like requirement for forecasting and reactive power compensation equipment. As per USAID auction toolkit (2020), the prime purposes of early auction creators are to reveal market interest and to commence the process of price discovery (see Figure 3). It says that in first auction, France quoted 88 MW solar PV for its first year; India 208 MW; Greece 40 MW for its pilot solar auction; and Poland quoted 8 MW for wind and 70 MW for solar.

Figure 3 Early auction objectives



Source: own creation based on RE auctions toolkit, USAID 2020

The auction features mentioned (see Table 1) can help to achieve the objectives of early auction in an effective way. Along with that in the early auction, auction designers should pay special attention to (1) the government having to take on the risk of land (i.e., land development, land allocation, site selection) and the participants in the auction taking on the risk of investment and operation; (2) auction will be called for high voltage power generation from RE (i.e., hub based RE); (3) enhancing competition as well as the efficiency of public sector, the government has to build up a public entity that will participate in the auction process along with private entities; (4) the qualification requirements must be easy but have to be focused on the benefits of local socio-economic development; and (5) emphasizing timely completion of RE projects.

Up to June 2020, only 650 MW of electricity produced from RE was added to the energy-mix in Bangladesh. Inconsistency with the different policies and lack of more effective actions are the significant barriers for achieving an RE target within a stipulated time frame. For this, aligning with the 'Draft National Solar Energy Roadmap of Bangladesh 2021–2041', the RE target can be set as follows (see table 2)-

Table 2 Proposed RE production and expected CO_2 emission reduction target for Bangladesh

Scenario		Unit 2020	Unit 2021-2030	Unit 2031-2041	Cumulative
BAU (10%)	Capacity (MW)	650	1,961	3,493	6,104
	GHG (MtCO2)	570,679	2,049,673	3,650,884	6,271,236
Medium Case (20%)	Capacity (MW)	650	3,922	6,986	11,558
	GHG (MtCO2)	570,679	4,099,346	7,301,768	11,971,793
Higher Medium Case (35%)	Capacity (MW)	650	5,086	15,547	21,283
	GHG (MtCO2)	570,679	5,315,475	16,250,168	22,136,322
High Case (50%)	Capacity (MW)	650	9,743	19,711	30,104
	GHG (MtCO2)	570,679	8,092,984	22,692,337	31,356,000

Source: Author's own creation based on 'Draft National Solar Energy Roadmap 2021-2041' for Bangladesh

As explained earlier, worldwide the technological advancement of the RE sector is eye catching and in near- future, development will be vigorous. Consequently, achieving any realistic target will not remain merely a dream. Here it must be mentioned that 24-hour if total electricity load is 100%, then 60% is all time load demand, 20% is intermediate load/day-peak demand, and 20% is evening-peak demand in Bangladesh. The justifications for setting target (see Table 2) for Bangladesh are (see Table 3):

Table 3 Justification of RE target setting in Bangladesh

Scenario	Cumulative Target (till 2041)	Justification to fit with RE Target
Business as Usual (BAU)-10% of RE of total electricity production	• 6104 MW RE • 6271236 $MtCO_2$ emission reduction	Being coherent with various policies (i.e., energy policy, power sector master plan 2016) set by the government of Bangladesh
Medium case-20% of RE of total electricity production	• 11558 MW RE • 11971793 $MtCO_2$ emission reduction	20% is intermediate load, i.e., day-peak demand is met-up by liquid fuel. Per unit liquid fuel cost: furnish oil 0.11 USD and LNG 0.10 USD. If per kWh RE generation especially solar cost is below 0.10 USD, then the target will be achieved. Recent global

		price trend shows that RE generation cost is below 0.10 USD/kWh. Again, currently 16 rental & quick rental power plants are active in Bangladesh whose capacity is 1109 MW and its per kWh generation cost is 0.099 USD. The contact tenure of these plants will be ended in 2024 (source: Bangladesh Power Development Board). It is a debatable issue whether the government should run the rental & quick rental power plants considering environmental issue. If the contact tenure is not being extended further, then this Cen percent share can be replaced by RE.
Higher Medium case-35% of RE of total electricity production	• 21283 MW RE • 22136322 $MtCO_2$ emission reduction	Bangladesh foresees rapidly moving towards a developed economy by 2041. Currently it is developing one. When it adopts that direction then economic progress and industrialization will be further expedited, then the evening-peak demand will be shifted along with intermediate load. Then 35% target of 40% demand (i,e., 20% day-peak demand plus 20% evening-peak demand total 40%) can be covered by RE analyzing economic viability, i.e., generation cost below 0.10 USD/kWh.
High case-50% of RE of total electricity production	• 30104 MW RE • 31356000 $MtCO_2$ emission reduction	Time to time revision of policy, technological advancement of RE, robust expansion of RE sector in Bangladesh, and matching-up with grid integration & variable renewable energy (VRE) will help to reach that aim.

Source: Author's own creation

In addition to the discussion of this paper, some supplementary recommendations practiced by developed countries for RE-support for obtaining high level expansion of RE can be presented as follows, which can be treated as WAM (with additional measures):

- Reliable and perfect RE mapping are required, i.e., determine solar and wind hubs for getting full advantage of RE;
- Set realistic RE target and coherence of all policy documents for chasing a single goal;

- Use of innovation technologies, i.e., energy storage, increase capacity of existing network elements, and operating modes, i.e., demand side responses;
- Independent aggregators especially for energy communities, i.e., relation to households and small corporate consumers for exchanging day-ahead market (DAM) and intra-day market (IDM);
- Obligatory Solar Home System (SHS) and net metering for new high-rise buildings, industries and commercial establishments including Export Zones (EZs) and Export Processing Zones (EPZs);
- Fix a single responsible point for achieving the RE target within stipulated time period avoiding the involvement of other energy segments;
- Interest free/negligible level of interest (2%-3%) based credit scheme for supporting, operating, and integrating RE generation market;
- Development of metrological centers by supporting high level of forecasting to the national load dispatch center for taking prior back-up plan to generate electricity from conventional sources;
- Introduce policy for large storage system (grid) for peak-shifting and saving for load/generation and eliminate variability in RE generation;
- RE deployment should be connected with 'Distributed Renewable Energy (DRE)';
- Develop regional cooperation in the RE sector, such as Renewable Energy Coordination Group (RECG) for trading cost-effective cross-broader RE;
- Set up standard RE quality control department (QCD) for standardization of RE accessories;
- Initiate 'Green Tariff' for RE sector;
- As electric vehicles (EV) are a good source of energy storage, government should take initiatives to promote their use;
- Improve specialized education for the labor market in the RE sector;
- Improve employment prospects in the green energy sector;
- Allocate subsidy/incentive for a huge expansion of the RE sector.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or individual connections that could have influenced the work presented in this paper.

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