

Performance of Renewable Energy Auctions

Experience in Brazil, China and India

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Abstract

This paper considers the design and performance of auction mechanisms used to deploy renewable energy in three emerging economies: Brazil, China, and India. The analysis focuses on the countries' experience in various dimensions, including price reductions, bidding dynamics, coordination with transmission planning, risk allocation strategies, and the issue of domestic content. Several countries have turned to public competitive bidding as a mechanism for developing the renewable generation sector in recent years,

with the number of countries implementing some sort of auction procedure rising from nine in 2009 to 36 by the end of 2011 and about 43 in 2013. In general, the use of auctions makes sense when the contracting authority expects a large volume of potentially suitable bids, so that the gains from competition can offset the costs of implementation. A study of the successes and failures of the particular auction design schemes described in this paper can be instrumental in informing future policy making.

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Performance of Renewable Energy Auctions: Experience in Brazil, China and India

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1 INTRODUCTION

Over the last two decades, many developed and developing countries have introduced a combination of incentives to promote grid-connected and off-grid renewable energy (RE) in support of multiple policy objectives – including, among others, enhancing energy security, reducing GHG emissions, improving local environmental sustainability, and increasing energy access. REN21 (2013) identified 127 countries with active renewable energy support policies in the beginning of 2013. Still, an analysis of the policies currently in place reveals that there is a very wide diversity in the mechanisms adopted by governments to meet this common goal; and as the sector matures revisions to existing policies have become increasingly common. A large body of literature has been developed reporting on the features and performance of different types of such policy mechanisms (see e.g., Kwant 2003; Finon and Perez 2007; Nilsson, Nilsson et al. 2009; Barradale 2010; Lee and Shih 2010; Lüthi and Prässler 2011; Zhang, Li et al. 2011; Kitzing, Mitchell et al. 2012; Fouquet 2013; Zhao, Tang et al. 2013; del Río and Cerdá 2014; Fais, Blesl et al. 2014; Gürkan and Langestraat 2014; Mir-Artigues and del Río 2014).

We consider one popular policy instrument; auction mechanisms. Early implementations of this type of scheme had a poor performance, leading most countries to lean towards other types of mechanism such as feed-in tariffs (FIT) and renewable purchase obligations (RPO). More than a decade later, however, a “second wave” of interest in RE auctions, largely led by emerging countries, has been gaining momentum (see e.g., Butler and Neuhoff 2008; Nielsen, Sorknæs et al. 2011; Buckman, Sibley et al. 2014; del Río and Linares 2014; Mayr, Schmidt et al. 2014). This paper provides analysis of three instances of auction-type mechanisms being adopted by three emerging countries – Brazil, India, and China. These countries have been selected for the significant volume of renewable energy deployed through auctions and experience accumulated over the last decade; and our main goal is to provide a condensed analysis that highlights how the various countries’ particular underlying circumstances and choice of auction design features have played a role on the ultimate success or failure of this type of scheme.³

2 RENEWABLE ENERGY AUCTIONS

There is a large body of literature reporting on the features and performance of different types of RE support mechanisms – see for example: Mananteau, Finon et al (2003), Kreycik, Couture et al (2011), Elizondo-Azuela and Barroso L. (2012), Wang X. (2012). In auction-based mechanisms⁴, both price and quantity are determined in advance of the decision to build the projects, under a public bidding process. Because of this characteristic, auctions can in a sense achieve the “best of both worlds” of FITs and

³ We have presented our figures in US dollars whenever applicable – implementing an exchange rate of 2.2 BRL/USD for Brazil, 60 INR/USD for India, and 6.1 CNY/USD for China³. However, it is difficult to estimate how investors have handled exchange rate volatility over this period – the Brazilian real remained relatively stable over the last decade (although it experienced some devaluation in the last couple of years), while the Indian rupee underwent nearly a 20% depreciation since 2011 and the Chinese yuan appreciated by nearly 25% since 2005. In addition, the three countries’ very different tax structures, capital costs and labor costs (among other elements) all represent confounding variables that make it difficult to make meaningful comparisons. For this reason, any cross-country comparisons of the values in U.S. dollars presented throughout this paper should be made with caution.

⁴ For the purpose of this paper, the expressions “concessions”, “competitive bidding”, “tenders”, and “auctions” will be used interchangeably to refer to the type of scheme detailed in this section.

RPOs, providing stable revenue guarantees for investors (similar to the FIT mechanism) while at the same time ensuring that the renewable generation target will be met precisely (similar to an RPO). While auctions have proven to be strong mechanisms for ensuring economic efficiency as they minimize the level of subsidy required, they have also been criticized for their higher transaction costs and subpar performance in terms of deployment rates (delayed or cancelled constructions).

Auction-based schemes aiming to foster renewable generation sources were a relative latecomer to the international scene, and a few early setbacks delayed their widespread adoption by several years. The United Kingdom’s Non-Fossil Fuel Obligation (NFFO) scheme, introduced in 1989, pioneered the usage of this type of mechanism; but the results were not very positive: there were major concerns with underbuilding, as only 391 MW of wind capacity were effectively built out of a total 2659 MW awarded, and the fact that the NFFO was regarded as much more complex than alternative FIT schemes certainly didn’t help matters (Pollitt, 2010). Ultimately, the UK abandoned the auction mechanism, switching to an RPO scheme in 2002.

In large part due to this negative early experience, the international dissemination of auction schemes was very slow at first. However, this stance has changed radically over the past few years, as illustrated in Table 1 – between 2005 and 2013, while the number of countries implementing FIT or RPO schemes roughly doubled in size, countries implementing auction schemes increased six-fold. It is also interesting to remark that much of the renewed interest in auction mechanisms has been led by developing countries – this skew towards upper-middle income countries or lower⁵, as opposed to RPO schemes’ greater concentration in high income countries, is shown in Figure 1.

As a result, auction mechanisms have become an important topic that has caught the attention of multiple investors, governments, and multilateral agencies.

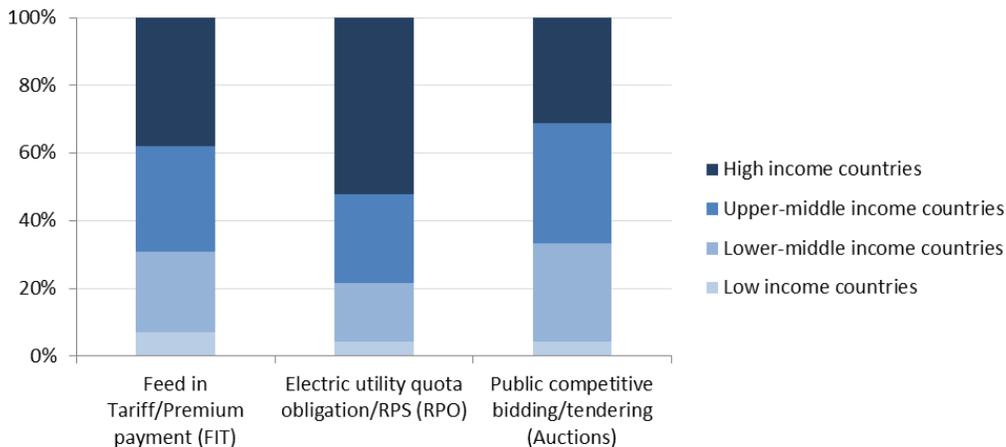
Table 1 – Number of countries with active renewable policies of various types

Mechanism	Number of countries with active policies	
	2005	2013
Feed in Tariff/Premium payment (FIT)	34	71
Electric utility quota obligation/RPS (RPO)	11	23
Public competitive bidding/tendering (Auctions)	7	45

Source: REN21 (2005), REN21 (2013)

⁵ Defined as countries with a gross national income per capita equal to 12,475 US\$ or lower, according to 2012 World Bank classifications

Figure 1 –Countries implementing renewable fostering policies in 2013 by income category



Source: REN21 (2013)

In part, the recent rise in popularity of auction schemes can be attributed to a rekindling of the debate on the tradeoffs involved in various candidate policies, motivated by the recent perceived failings of FIT implementations for solar photovoltaics (PV) in particular. In countries such as Spain and Germany, the technology’ leveled cost had been falling at such a fast pace that FITs remained above market equilibrium prices for an extended period, resulting in an oversupply situation as investors rushed to the market – and the remuneration for these additional generators, ensured by the FITs, will ultimately need to be burdened by the consumers. This event has made policy makers more cautious with respect to the potential downsides of FIT schemes, and likely had a role in the rise in popularity of alternative policies such as feed-in premiums and auction schemes (Batlle C., et al, 2012).

Most recently, the European Commission (EC) issued a communication document that discusses the issue of public intervention in internal electricity markets in which it provides specific guidance on policy support to renewable energy (European Commission, 2013). According to this guideline, FIT mechanisms for promoting renewable energy can be expected to be phased out over time in favor of auction-type mechanisms, further cementing the trend that has been observed over the past few years.

Simply defined, 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 major roles 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.

On the other hand, auctions tend to be costly, both to the organizing agency and to participants; and problems with delays and underbuilding of the auctioned projects have been a recurring concern. In general, a strong institutional capacity and a large expected volume of market-ready potentially suitable bids are required in order to justify the effort of organizing the procedure. Competition among bidders is at the heart of the auction mechanism, and the success of the auction relies on the country’s ability to

attract potential investors and financiers, as well as on the availability of candidate projects – with resource assessments, feasibility studies and permitting processes already in a fairly advanced stage before the auction is launched.

Beyond these common elements, however, auction-type mechanisms can differ very much from one implementation to the next – multiple defining traits can be adjusted to best accommodate a particular country’s needs. While this characteristic can be a plus (auctions are very adaptable instruments), it also makes it harder to make cross-country comparisons and obtain policy recommendations. Some of the most important elements at the core of an auction design scheme are as follows:

- *Supply and demand specification*: This element determines who can effectively participate in the auction and how much product will be contracted. In RE auctions, the quantity to be contracted is typically determined by government policy, either in terms of energy units, capacity units, or other – in more sophisticated mechanisms, for example, this demand can be allowed to vary in function of the auctioned price. On the supply side, the auction mechanism may restrict bids to particular types of technologies or sites; and this restriction may take place at several levels (technology-neutral, technology-specific, location-specific, or even project-specific auctions have all been common⁶).
- *Winner selection process*: Typically, the winner of the auction is determined simply by the least-cost bid – however, it is not uncommon to incorporate other decision criteria, introducing a compound “index” that ranks the candidates. Another element to be defined is whether the auction includes a (disclosed or undisclosed) price cap, and how bidders’ ultimate remuneration will be determined based on their bids – first-price, second-price, and pay-as-bid being some of the more common implementations. The price discovery mechanism is also an important decision point: the choice between sealed-bid auctions and descending clock auctions involves a consideration on whether the descending clock auction’s better price discovery offsets the increased risk of strategic or collusive behavior among participants. Some countries (Brazil in particular) have implemented hybrid systems in an attempt to combine the best design features and enhance efficiency – in this case, the tradeoff is chiefly associated with the greater complexity of the hybrid mechanism.
- *Product characteristics*: Typically, the product offered to the winners is a long-term power purchase agreement (PPA) – some important components being contract duration, escalation/indexation clauses, and liabilities of the contract parties. The enforceability of the contract terms, including the choice of the contract counterparty and the mechanism for collecting payments from consumers and/or taxpayers, can have a direct influence on the generators’ financial risk. In addition, depending on how the generator’s obligations are defined, an accounting/settlement mechanism to deal with RE production intermittency must usually be defined as well. Generally speaking, offering a more attractive product (i.e. one that protects investors from multiple sources of risk, such as counterparty risk, inflation risk, exchange rate risk, market price risk, and renewable resource availability risk) will tend to increase the number of potential participants in the auction and decrease the price bids, at the cost of transferring these risks to consumers. Risk allocation is a very important consideration for the auction design.

⁶ Some authors refer to project-specific auctions as “tenders”. In this paper, we will use the denomination of “auctions” without highlighting this distinction.

- *Requirements and penalties:* These terms help to ensure that the winners' obligations will be fulfilled. Some of the standard practices include pre-requisites to register projects to participate in an auction, bid bonds (to be executed in case bidders' obligations are not met), completion bonds (to be executed if project milestones of the auction winners are not met), and the possibility of contract termination after a predetermined period of delay. Sometimes, guarantees of the bidders' financial health are also required at the registration stage, in order to prevent "adventurous" bidding that is unlikely to materialize. Because delays and underperformance have been recurring concerns of renewable auction implementations (as illustrated by the UK's experience in the 1990s), establishing a set of harsh, credible penalties can be an important first step to minimize this issue.
- *Strategy and coordination:* Because auctions offer a full disclosure of projects that will be built ahead of time, multiple attempts have been made in order to best coordinate these renewable capacity additions with the expansion of the transmission grid and of the generation system as a whole. On a higher level, it is also interesting to coordinate the installation of renewable generation capacity with the development of the country's manufacturing industry – in several implementations, minimum domestic content requirements were added to the power purchase agreement (PPA) terms as a means to forward this goal. Setting clear goals and signaling to the market the intent of organizing periodic auctions over an extended period of time can also indirectly promote coordination, by allowing industries to plan for the longer term.

3. THE CASE OF BRAZIL

3.1 Background

Electricity auctions are at the core of the regulatory framework that Brazil adopted after reforming its electricity market in 2004. Since then, periodic energy auctions have made possible the construction of 58 GW of new generation capacity (46 percent hydropower and 29 percent from other renewable sources), through about \$350 billion in long-term contracts.¹ This extensive experience allows a quantitative data-based assessment of the strengths and weaknesses of the country's auction scheme and its application to renewable energy development. Wind power development is especially interesting because it has progressed in two very distinct stages, both using auctions (Cunha, Barroso, and Bezerra 2014; Cunha and others 2012). The first stage was marked by a strong will to promote the development of nonconventional renewable sources of energy. Even though Brazil has historically relied on the continuous development of large hydropower generation—hydropower represented 70 percent of the country's total installed capacity of 120 GW at the end of 2012—large amounts of small hydro, wind, and biomass potential remained untapped. The main challenge of this first stage was to create conditions that would allow those sources not only to emerge in the energy mix, but possibly to become competitive with conventional sources. Contracts were specifically designed to accommodate the characteristics of individual technologies, aiming to attract more investors by offering an attractive product that would shield them from several unmanageable risks—such as inflation and the uncertainty of variable generation. The results of the first stage were wildly successful: The renewable auctions were very competitive, drawing large investments from both the public and private sectors,² and allowing consumers to benefit from cleaner energy at lower prices.

However, the success of the wind auctions brought other challenges. Critics complained that the terms offered in contracts were too generous for investors and that, as a result, generators had an incentive to bid aggressively and to make unrealistic promises about their plants' likely performance. Note that regular energy auctions in Brazil have the express objective of ensuring adequate system expansion. While this is an important concern in any country where demand for electricity is growing rapidly (over the past decade, Brazil's demand has grown by 4.3 percent per year, on average), in Brazil there is also the need to maintain an optimal management of hydropower reserves: If the system is undersupplied (that is, if there is not enough firm generation capacity to meet demand), reservoirs will deplete faster, which could increase the risk of energy shortages.

Therefore, when the first stage of wind farm development through auctions progressed to the point where wind-based capacity began to constitute a significant fraction of system expansion, security of supply became a concern. These concerns defined the second stage of wind power development in Brazil, which is the main topic of this note. The Brazilian government began to tackle some of these issues in 2013, revising some aspects of the auction design introduced in 2009 and seeking an optimal allocation of risk in the contracts offered to wind producers.

3.2 Early design and objectives

The 2004 Brazilian market reform introduced several types of energy contract auctions aiming to achieve different policy objectives – separate auctions for procuring electricity from new plants and existing plants were envisioned, as well as project-specific auctions for large hydro plants and technology-specific

auctions for contracting renewable energy (among other objectives). With regards to promoting the development of renewable energy, two types of auction have been most important: the regular new energy auctions and the reserve auctions.

Regular new energy auctions are carried out twice per year, for delivery 3 and 5 years ahead respectively. The main goal of this type of auction is to procure energy and firm energy certificates (FECs) to ensure adequate system expansion – the demand for those auctions is reported by distribution companies according to their expected load growth and aggregated by the auctioneer.⁷ Regulated consumers pay the full cost of energy. While usually technology-neutral, restrictions to the participation of certain technologies have been imposed in the past: a couple of auctions dubbed “auctions for non-conventional sources”, in practice having the same design elements as the regular new energy auctions, have been exclusive to RE.

Reserve energy auctions are carried out sporadically at the government’s discretion – the auction demand is determined by the government and all consumers pay for the energy through a tariff surcharge. The contract counterparty is a centralized Electricity Trading Chamber⁸. These auctions were designed as a mechanism for the government to contract supplementary (or surplus) energy to increase the system’s reserve margin; and they have been extensively used to promote renewable energy in Brazil.

The most important difference between these two types of auction is that in the reserve auctions the generators do not have the explicit financial obligation to provide FECs to consumers⁹; and therefore downside risks to investors are mitigated. Another distinction, which has generally been treated as fairly minor, is the slightly lower counterparty risk in the case of the reserve auctions – distribution companies tend to be less bankable parties than the electricity trading chamber, although the fact that regular new auction winners sign individual PPAs with multiple distribution companies tends to mitigate this concern¹⁰. These characteristics (among others) made reserve auctions an interesting alternative for policy makers to introduce renewable fostering mechanisms – indeed, all reserve auctions conducted in Brazil to date have been exclusive to RE (either restricted to a particular technology or allowing competition among biomass, wind, and/or small hydro).

Wind power plants made their debut in the Brazilian electricity sector in a wind-exclusive reserve auction in 2009, which introduced an attractive contract specifically catered to the needs of wind based generation. Auctioned contracts included mechanisms for annual and 4-year settlements that greatly reduced the risk of wind variability and its impact on revenue.

Another defining trait of the early design of wind energy auctions was that the State went through great efforts to integrate transmission planning into the energy auction process, centrally designing a network expansion plan involving a multilayered system of shared collector substations conditional to the auction results. Based on this plan, the State would separately auction a concession to build the necessary transmission lines and substations; while the investor would not be liable for any delays in the interconnection works. The idea behind this scheme was that, because the auctions enabled the full

⁷ In the Brazilian regulation, a FEC is a certificated (denominated in GWh per year) for the maximum amount of energy that a plant can sell annually through contracts. FECs correspond to the net amount of electricity purchased through contracts plus a generator’s physical generation capacity, minus consumption.

⁸ CCEE actually centralizes the payments done by the more than 2000+ consumers in Brazil and provides payment guarantees for a few months in case a default is observed.

⁹ Under the Brazilian FEC scheme, any agent that has a negative FEC balance is subject to heavy penalties.

¹⁰ Recent financial problems faced by multiple distribution companies indicate that this may not be a minor concern.

disclosure of the projects to be built in advance, it would be possible to achieve greater coordination and economic efficiency by centrally coordinating the planning effort in this manner¹¹.

Other design elements of the first Brazilian wind power auction were borrowed from earlier regular new energy auctions for other technologies – among them, the hybrid price discovery mechanism (descending clock phase followed by a pay-as-bid phase), escalation clauses linked to the Brazilian consumer price index (CPI), the periodic nature of the regular energy auctions, and the role of the Brazilian Development Bank (BNDES) as a financier and enforcer of domestic content. While the Brazilian auction design is generally more complex than most other worldwide implementations, the fact that those auctions play such an important role in the country's regulatory framework can help justify this greater complexity.

Mechanism revisions

As wind technology matured, and in part due to fiscal and financial benefits offered to the technology, wind power has become competitive in the regular new energy auctions as well – as wind power plants started to compete directly with conventional sources this way, it is implied that wind power is sufficiently reliable to contribute to security of supply, since they are displacing other generation sources in the system expansion.

Despite this important distinction, the core mechanism introduced in the 2009 reserve auction was maintained for several years with only minor adaptations : as long as the participation of wind power in total system capacity was small, concerns with wind plants' contribution to security of supply were not as important, which allowed the authorities to offer a similar attractive product for wind plants in the regular new energy auctions. In particular, the unique settlement mechanism with yearly and 4-year settlements was maintained; and the 2010 regular auction cemented the representation of wind plant's FECs as being proportional to their expected generation, without taking into account how its power injections would affect the system as a whole (hydro and thermal plants, in contrast, used more sophisticated methodologies). On the other hand, sellers in new energy auctions were allowed to sell their surplus electricity in the free market (rather than having it automatically allocated to the contract); and they were liable to contribute with FECs. This introduced some co-responsibility in case of delays in the transmission system – even though the generators would receive their contract revenue as normal, they would need to procure compensatory FECs (at market prices) in order to honor the contract.

These core elements were adopted in several reserve and regular auctions organized over the following years, only making minor adjustments in the ceiling price and in the candidate technologies that were allowed to compete with wind power in each auction. The first major revisions to this basic scheme have been carried out in 2013 – when the government decided that it was necessary to reduce some of the generous benefits that had been offered to the bidders in the first few auctions.

The first important change has been a revision in the calculation of the maximum amount of energy that wind plants can offer in the auction (and their FECs, in case of the regular auctions). Originally, wind farms' maximum contribution was equal to their *mean* (P50) certified wind production, calculated by an independent company based on historical wind measurements; but starting in 2013, wind farms could only offer in the auction the *P90* of their wind certification. Under this revised methodology, wind farms'

¹¹ See Rudnick, Barroso et al, 2012 for more information on this proposed scheme.

actual generation should be equal to or higher than their calculated certification in 90% of future years, resulting in a more conservative assessment of wind plants' contribution (all else being equal).

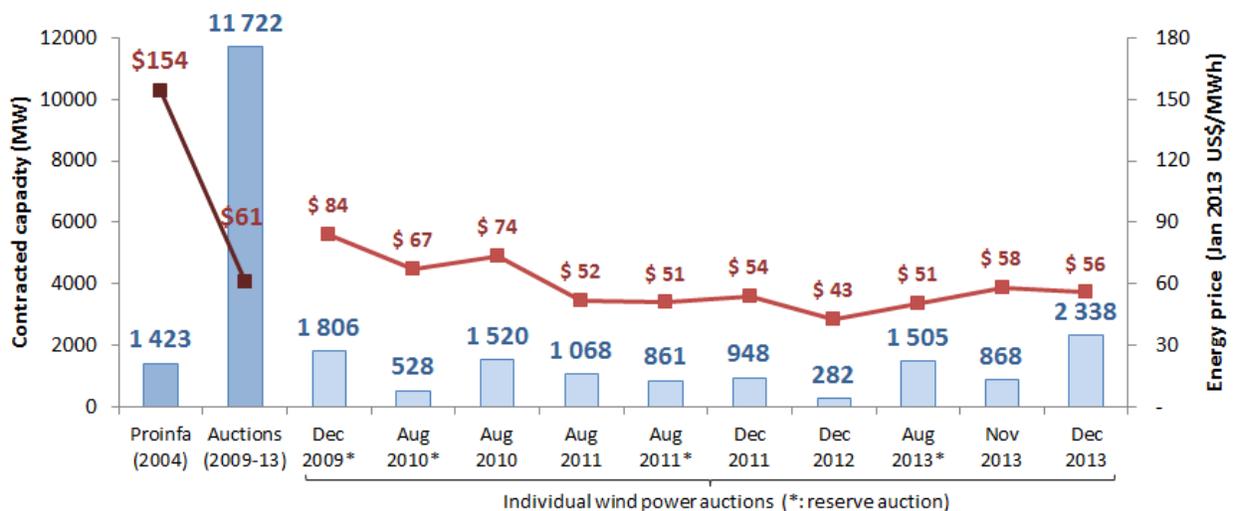
The second important element has been the handling of transmission delays. In 2013, the government discontinued the centralized planning of the transmission expansion – while very attractive on paper, in practice this scheme ended up facing major challenges, as it put transmission into a very tight schedule that left very little margin for errors. The 2013 reserve auction instituted a “pre-auction” for access to the existing available substations, and determined that carrying out the connection works until the substation was a responsibility of the investor. As a consequence, no wind power projects could be accepted if they would require an expansion of the high-voltage grid. This criterion was made more flexible in subsequent (regular) auctions: no pre-auction was held, as the need to procure compensatory FECs in case of transmission delays was considered a sufficient incentive for investors to organize any needed transmission expansion works.

3.3 Auction Performance

Results from the bidding stage

Wind power auctions were introduced in Brazil at a very appropriate moment – the 2008 economic crisis had strongly reduced demand for wind equipment in Europe, and there was an expectation that especially low prices could be achieved. However, price reductions driven by competition between national and international companies were even greater than anticipated, as illustrated in Figure 2 – compared to the Proinfa period, prices fell by nearly 45% in the 2009 auction alone, and then they fell by almost a further 40% in 2009-2011.

Figure 2 – Highlight on auctions involving wind power: Contracted amount and prices¹²

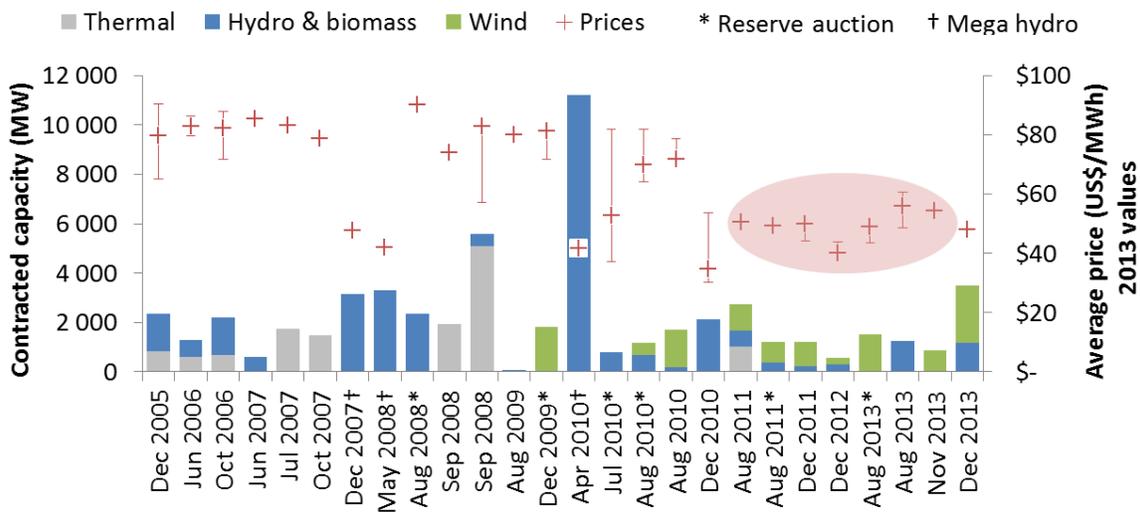


Source: Prepared by the authors

¹² All prices presented in this Chapter have been updated according to the Brazilian CPI (IPCA), as per PPA's indexation terms; and converted using an exchange rate of 2.2 BRL/USD (representative of the mean exchange rates of the first quarter of 2014).

Due to these significant price discounts, wind farms' participation in the regular new energy auctions over the past few years has contributed to bring down the price of new generation in Brazil as a whole. Figure 3 shows a history of all auctions for new capacity that have been carried out in Brazil since the 2004 market reform. Noticeably, between 2005 and 2009 auctioned prices had been rather stable at around 80 US\$/MWh (except for three mega hydro auctions); but after 2011 those prices seem to have stabilized around a lower value of ca. 50 US\$/MWh. Because these price reductions were simultaneous with the advent of wind power as a competitive generation source, a reasonable judgment is that the development of the wind power industry in Brazil contributed to increase competition in *conventional* energy auctions, driving down investors' profits and allowing consumers to capture the benefits of the resulting lower prices.

Figure 3 – History of Brazilian auctions, highlighting the new price paradigm



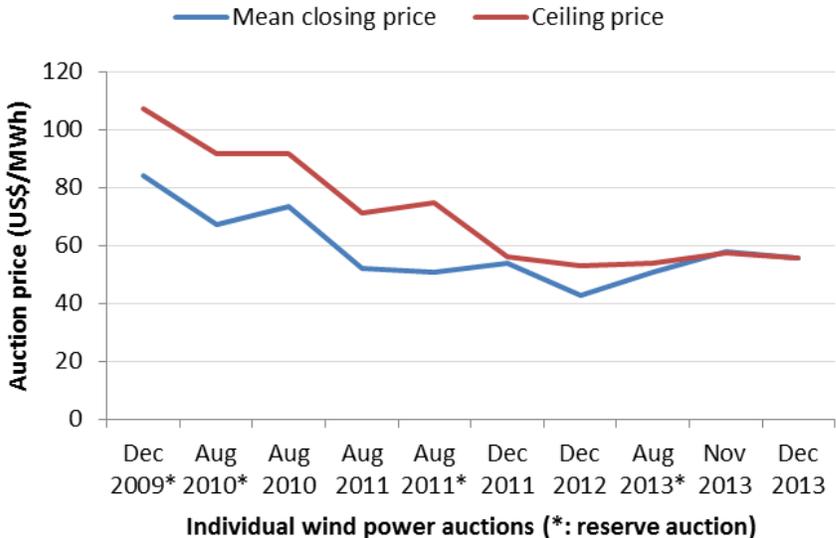
Source: Prepared by the authors

More recently, concerns have been raised with regards to the reasonableness of the bids and sustainability of the Brazilian wind auction mechanism going forward. Given usual financing conditions and typical investment and operation costs, there are concerns that the bids in the most recent auctions have been below the level that could sustain the wind power supply chain, increasing the risk of construction delays or defaults by the winners that placed unrealistic or adventurous bids. This concern has been compounded by the fact that the auction's ceiling price¹³ has been a much more constraining parameter in the most recent auctions, as illustrated in Figure 4. This indicates that, if prices dipped below their optimal level in past years, they have been unable to rise back to a more reasonable level, since the government has repeatedly lowered the ceiling price and did not sufficiently adjust it upwards even though the redesign of some aspects of the auction mechanism in 2013 (as described in the previous section) could justify an increase in the investors' remuneration.

¹³ The Brazilian auction mechanism involves a two-phase hybrid scheme, so that the auction price ceiling is the opening price of the first phase (descending clock auction).

The Brazilian government’s strategy of adopting tight ceiling prices seems at odds with the country’s past experience, since in the earlier auctions competition among suppliers was the most important contributor, driving prices significantly below the ceiling. In addition, especially for the regular new energy auctions, this strategy introduces a risk of compromising security of supply if auctioned demand is not met. Despite the abundance of candidate suppliers – more than 9,000 MW of wind power plants enlisted for each of the last four Brazilian auctions, outnumbering the demand for new capacity by at least five to one in each of them – having a marginal price so close to the ceiling price (as illustrated in Figure 4) indicates that has been barely any competition in recent auctions, with many suppliers dropping out immediately and others simply offering the ceiling price.

Figure 4 – Comparison between auction ceiling price and closing price



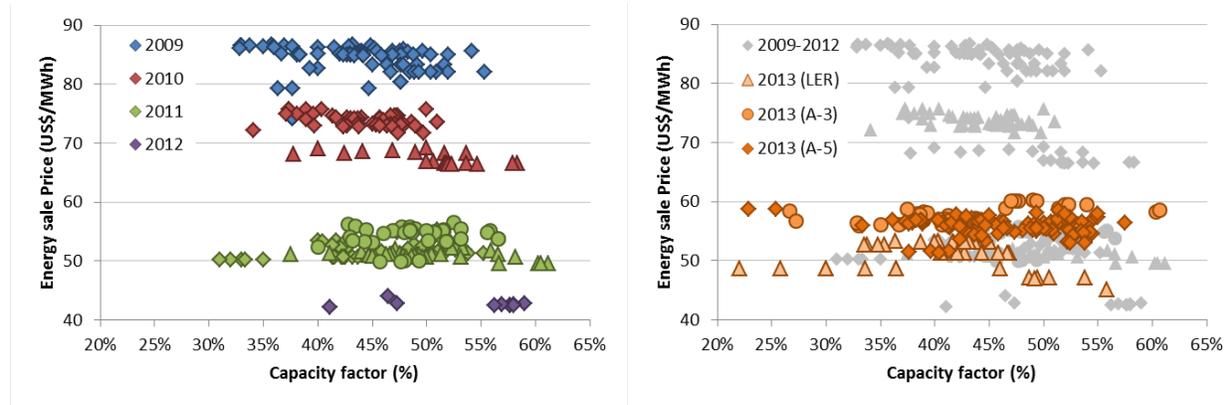
Source: Prepared by the authors

Another concern has been the increasingly large capacity factors that have been declared by the bidders over the years, as illustrated in Figure 5. While the auction mechanism should provide a price signal for investors to seek better wind resources, the capacity factors in excess of 50% that have been claimed by some entrepreneurs should be regarded with skepticism. A strategy of “aggressive certification” (carefully selecting the best years of wind measurements) may have been used to obtain these extremely high capacity factors, potentially with the goal of exploiting the wind contract’s favorable settlement rules: in practice, if a plant underperforms, the consumer will bear the burden of at least a portion of the resulting costs instead of the investor.

The fact that even after the design modifications of the 2013 auctions there are several outliers sporting very high capacity factors (even though the average declared capacity factor was reduced, as seen in Figure 5) is also troubling. Even though it is *more difficult* for generators to overstate their certified annual generation (because of the more conservative P90 approach), the *incentives* for generators to do so

remain in place – and therefore this one-time reduction is not likely to bring capacity factor estimates back to more reasonable levels over the longer term.

Figure 5 – Capacity factor scatterplot – winners of energy auctions



Source: Prepared by the authors

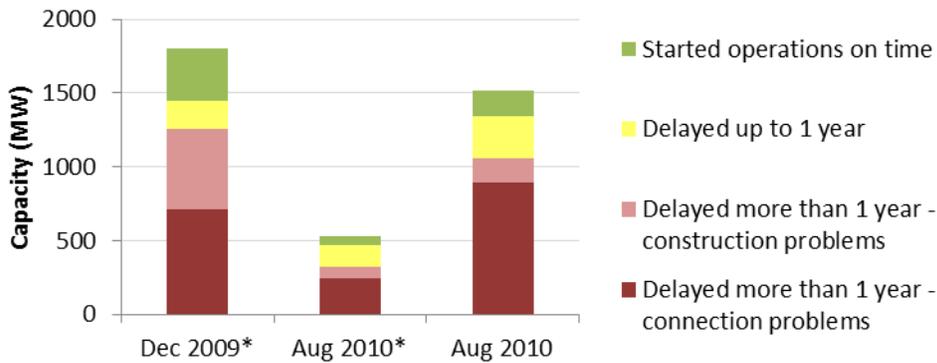
Construction and generation performance

One of the largest and most pressing concerns for Brazilian policy makers has been the extremely large delays that many of the auctioned projects have been experiencing. As illustrated in Figure 6, almost 70% of the wind capacity contracted in the first three Brazilian wind auctions (which should have started operations in 2013) was delayed for more than one year, and almost 70% of those delays have been attributed to problems in the construction of the transmission lines and substations that would connect them to the grid¹⁴. This issue was one of the major reasons for the Brazilian government discontinuing its proposed scheme of generation-transmission co-planning in 2013.

However, it is relevant to remark that generators' ability to start operations on time has been less than stellar, even after disregarding the delays attributed to transmission issues. Only 30% of the capacity was commissioned on time, and 40% suffered delays greater than one year. Difficulties have been related to difficulties to close project financing and project management issues. This is despite the relatively harsh penalties imposed by the contract, such as execution of the completion bond (5% of the declared investment cost) and the possibility of contract termination in case delays are greater than a certain threshold (varies by contract, but usually 1 year).

¹⁴ Most of these problems can be traced back to difficulties with environmental licensing and managerial shortcomings of the winners of the transmission auction.

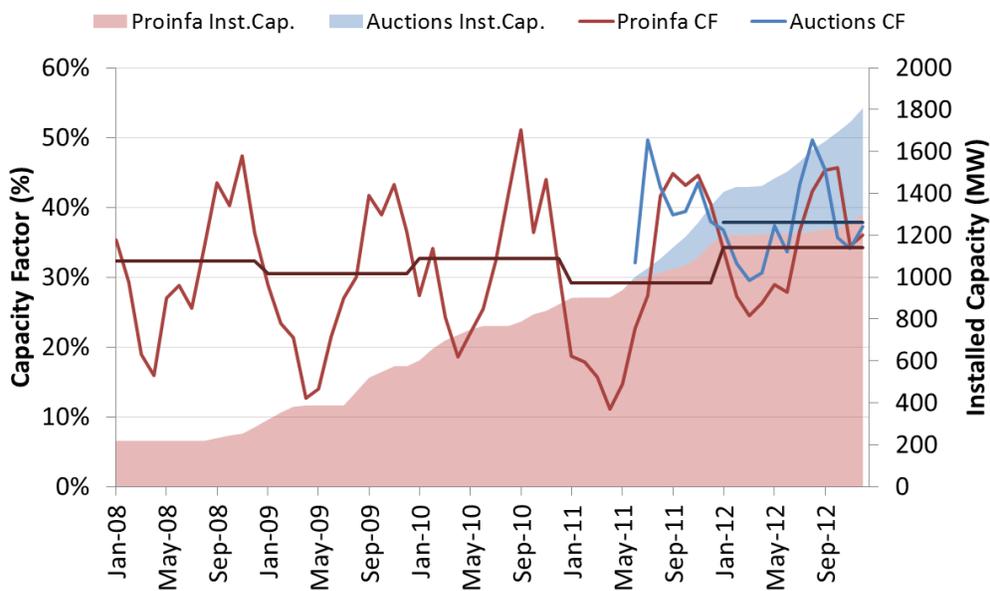
Figure 6 –December 2013 status of the projects auctioned in the first three Brazilian wind auctions



Source: Prepared by the authors

While there is a relatively small amount of auctioned capacity already online (largely due to the issues with delays), Figure 7 illustrates the historical capacity factors of wind plants in Brazil, classified into Proinfa plants and auctioned plants. Because the Proinfa mechanism offered very limited incentives for the most productive sites to win the auction (the main selection criterion was based on the date of the project’s environmental license), it is to be expected that the auction schemes would result in slightly better capacity factors. While the short track records of the wind farms (coupled with intrinsic climate variability) make this issue difficult to assess, the results so far have been very much in line with this expectation – auctioned wind plants reached a 38% capacity factor on average in 2012, outperforming the Proinfa plants but falling short of the certified capacity factor of ca. 44% (even though wind conditions were apparently better than average, as indicated by the Proinfa plants’ performance).

Figure 7 – Past performance of wind generation in Brazil



4. THE CASE OF INDIA

4.1 Background

Although India is the fifth-largest electricity consumer of the world, with an installed capacity of 211 GW as of the end of 2011, the country's energy sector still has immense potential for growth. A quarter of the country's population lack access to electricity, and yearly electricity consumption per capita stands at just 684 kWh, less than a third of Brazil's and around a fifth of China's.

Solving India's significant supply-side problems would open major opportunities for load growth, and renewable generation could be an important part of such a scenario. Renewable energy—notably wind and solar—has played an important role as a complement to India's coal-based electricity generation mix.

Attractive fiscal and financial incentives introduced in the 1990s favored the growth of the Indian wind energy sector, to the point that by the end of 2012 the country ranked fifth in the world in installed wind power capacity (19 GW).

When India decided to launch its Jawaharlal Nehru National Solar Mission (NSM) in January 2010, policy makers aimed to do for solar power what the previous policies had done for wind, enabling the Indian solar power sector to become an important international player. However, solar energy was not as close to competitiveness in the Indian context as was wind power, requiring greater efforts from policy makers to reach the expansion target.

Under the NSM, the central government initially organized energy auctions to procure new solar capacity. For the longer term, much of the capacity expansion was to be decentralized to the state level. Motivated to design their own solar policies and targets, many of the state governments adopted auction mechanisms as a central scheme to achieve their goals, inspired largely by the central government's initiatives. Because the Indian experience was varied, with implementation tailored to local circumstances, the case presents valuable lessons of experience.

4.2 Early design and objectives

In the National Solar Mission (NSM) delivered by the Ministry of New and Renewable Energy (MNRE) in 2010, competitive bidding was singled out as a key supporting mechanism due to its capacity to ensure adequate price discovery, especially for the contracting of pilot and demonstration projects.

Because of the relatively incipient stage of development of the solar technology in India at the time, the NSM was designed to give great importance to auction mechanism in earlier stages – in Phase I, encompassing years 2010 to 2013, the NSM aimed to build between 1,000 and 2,000 MW of grid-connected solar power; and 1,000 MW of this amount (between 50% and 100% of the target) was to be contracted through the NSM Phase I centralized auctions.

In the long term, it was expected that solar capacity additions in India would become more and more reliant on other mechanisms – most notably a national Renewable Purchase Obligation (RPO) scheme that would guide state-level initiatives. Indeed, the expectation was that state policies would be responsible for 60% of solar capacity additions in 2013-2017, during Phase 2 of the NSM (MNRE, 2012).

This decentralized scheme would require efforts in harmonizing policies, improving coordination, and sharing of best practices among states.

While the NSM aimed to maintain neutrality with respect to the choice of solar technology that would be developed to achieve its targets, the centralized auctions carried out in Phase I predetermined an equal volume of supply between concentrated solar power (CSP) and solar photovoltaic (PV) technologies (500 MW each).

Although the CSP technology had a much smaller track record in international implementations (1.1 GW of CSP plants were operational worldwide as of end 2010, vs. 40 GW of solar PV – REN21, 2013), there were great expectations regarding the technology's potential in India. CSP projects imposed more stringent limitations on project design, requiring longer construction periods and larger-scale projects to become viable, but among solar technologies they exhibited the lowest costs in the first of the Phase I auctions (over the years however, solar PV experienced more dramatic price reductions).

Ultimately, two auctions have been carried out under the NSM Phase I – in August 2010 for 150 MW of PV capacity and 500 MW of CSP capacity, and in August 2011 for 350 MW of PV capacity. The design elements on these two auctions were essentially the same – bidding was carried out in a closed-envelope, pay-as-bid fashion, with fully disclosed ceiling prices¹⁵.

In addition, the auction rules explicitly established a hard domestic content requirement (DCR) on crystalline silicon PV modules to support the manufacturing of this technology in India.

The product offered in the NSM Phase I auction was a 25-year duration PPA with no escalation clauses. The contract used the so-called “bundling” scheme to organize the payment streams and minimize the impact of solar power contracts on consumers' electricity tariffs. Under this mechanism, the contract counterparty (NVTN) would organize “bundles” of solar power and cheap thermal power for sale to consumers, “diluting” in this way the higher costs of the solar technology in the bundled electricity portfolio. Since the NVTN is a subsidiary of the profitable state-owned National Thermal Power Corporation, this mechanism also offered reliable guarantees to generators with respect to the contract counterparty – however, a limitation to the widespread adoption of the “bundling” is that it requires the availability of cheap, uncontracted thermal power.

In the first NSM auction the state transmission company was responsible for the investments in the transmission grid necessary to connect the solar plants. However, the plant would not be considered operational unless the evacuation facilities were also ready – this created a problem to investors and project developers because they would be penalized for delays in the interconnection with the grid without having control over the works. This scheme was scrapped almost immediately – the second Phase I NSM auction left the responsibility of carrying out any connection works to the investors.

Mechanism revisions

After the auctions in Phase I, there was a two-year gap during which there were no national-level initiatives – and in the meantime, state-level solar programs gained importance. Auction schemes for the contracting of solar power have been carried out by the Indian states of Odisha, Karnataka, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Rajasthan, Punjab, and Uttar Pradesh. While none of these state-

¹⁵ Technically, participants bid a *discount* to the ceiling price

level initiatives have ultimately matched the scale and importance of either the national-level auctions or the Gujarat FIT mechanism (although some were originally much more ambitious), they have introduced some interesting auction design elements. Since each of the state governments is in position to design their own auction schemes, there are often several minor differences between auction implementations – however, it is worthwhile to discuss a few particularly interesting innovations.

One important consideration has been with respect to the payment structure – most states need to rely on the state distribution companies (Discos) as contract counterparties, and “bundling” schemes are rarely possible at the state level. The major issue in this case is that many of Discos are challenged with a poor financial performance, which increases financial risks to investors and drive away potential suppliers. The state of Rajasthan, for example, carried out a revision of its auctioned PPA to use the more bankable state nodal agency (RRECL) as the contract counterparty.

Perhaps the most notable – and most controversial – change implemented by the state-level auctions has been the lowest-bid (or “L1”) contract pricing scheme. Under this scheme, adopted by Odisha, Rajasthan, Tamil Nadu, and Andhra Pradesh, developers must meet the *lowest price* offered from auction’s participants in order to be awarded the PPA. The economic rationale for such a scheme is questionable – although it could be successful in depressing prices, in a competitive market the measure would simply lead to bidders refusing the PPA.

Another more recent innovation has been brought by the state of Uttar Pradesh, which offered a 10-year PPA as the auctioned product, rather than the typical 25-year contract. Given that the auctioned PPAs are not indexed to inflation over the long term, this shorter term contract could in fact represent an advantage to investors, since they would be free to sell the generated electricity at market prices after that period; also it would be reasonable to expect that electricity spot prices would escalate with fuel prices and investment costs of conventional generation, while the contract would gradually lose value in real terms due to the lack of any escalation clauses. In addition, the reduced certainty in the revenue streams after the 10-year mark would not be as impactful, since in general all loans are already repaid within that period.

In 2013, a different national-level RE procurement process was launched in the form of city-specific rooftop solar auctions organized by the (recently created) Solar Energy Corporation of India (SECI), which is subordinate to the Indian Ministry of New and Renewable Energy (MNRE). A combined 25.5 MW were awarded in three auctions organized in April, July, and December 2013; each of which was focused on a particular set of cities.

Rather than offering a long-term PPA, the SECI rooftop auctions involved a capital subsidy to be paid in three installments¹⁶: two-thirds at the time of plant commissioning (subject to a minimum performance ratio of 75%); one-sixth after 1 year of operations, and the remainder after the second year of operations (provided that the plant’s capacity factor has been equal to at least 15%).

The concern that the capital subsidy scheme could reduce investors’ incentives to maintain the plant at peak performance for the entire useful life of the plant (considering that a subsidy delivered upfront is not output based and that there is a reduced correlation between plant performance and revenue) should not be significant, since the project developer has the rights over the electricity generated by the rooftop facility over the entire plant’s lifetime.

¹⁶ This subsidy is equal to 30% of the expected investment cost declared in the auction

It is interesting to note that the use of bidding processes for procuring smaller-scale projects where the auctioned product is a capital subsidy is an unorthodox design – and the fact that this modification could be operationalized easily is a testament of the adaptability of the auction mechanism.

In February 2014, national-level auctions for large-scale plants were resumed. The contract counterparty for the auctions in Phase II was the same as for the rooftop auctions (SECI). There were several differences between the NSM auctions in Phase I and Phase II, which reflect multiple important developments that took place in India between 2010 and 2014.

Most noticeably, the auctions of Phase II introduced a “viability gap funding” (VGF) scheme which replaced the bundling scheme of Phase I auctions – partly due to constraints in the availability of thermal power to structure the bundles. The VGF mechanism, which had recently been approved as a funding source within the National Clean Energy Fund, was similar to the mechanism adopted in the rooftop auctions, in the sense that it involves a capital subsidy to be paid over the first few years of operation of the solar plant.

One difference is that the long-term revenue for the plants participating in these auctions would be ensured by a 25-year PPA, eliminating the option of free negotiations at market prices (as was the case for rooftop auctions). This modification enabled the enforcing of performance standards on a long-term basis including the requirement that the plant’s yearly capacity utilization factor remain within a certain percentage of the plant’s declared capacity factor for the duration of the PPA. The disbursement schedule for the VGF was also slightly different: 50 percent at the start of operations and 10 percent at the end of each of the first five years of operation; and subject to performance evaluations.

One element that has signified a major point of contention is the NSM domestic content requirement (DCR). Already an official complaint has been filed by the United States with the World Trade Organization (WTO) against the Indian NSM.

Most state auctions however did not introduce DCRs. The national rooftop auctions however did require that solar PV modules manufactured in India. In the Phase II auction, India split its demand for new solar capacity into two sub-auctions – one for suppliers with domestic content (Part A) and another open for all participants (part B). Implicitly, this allowed the Indian government to promote international competition (addressing the USA’s earlier complaint) while still favoring local manufacturers, by implicitly accepting a higher price in the Part A auction.

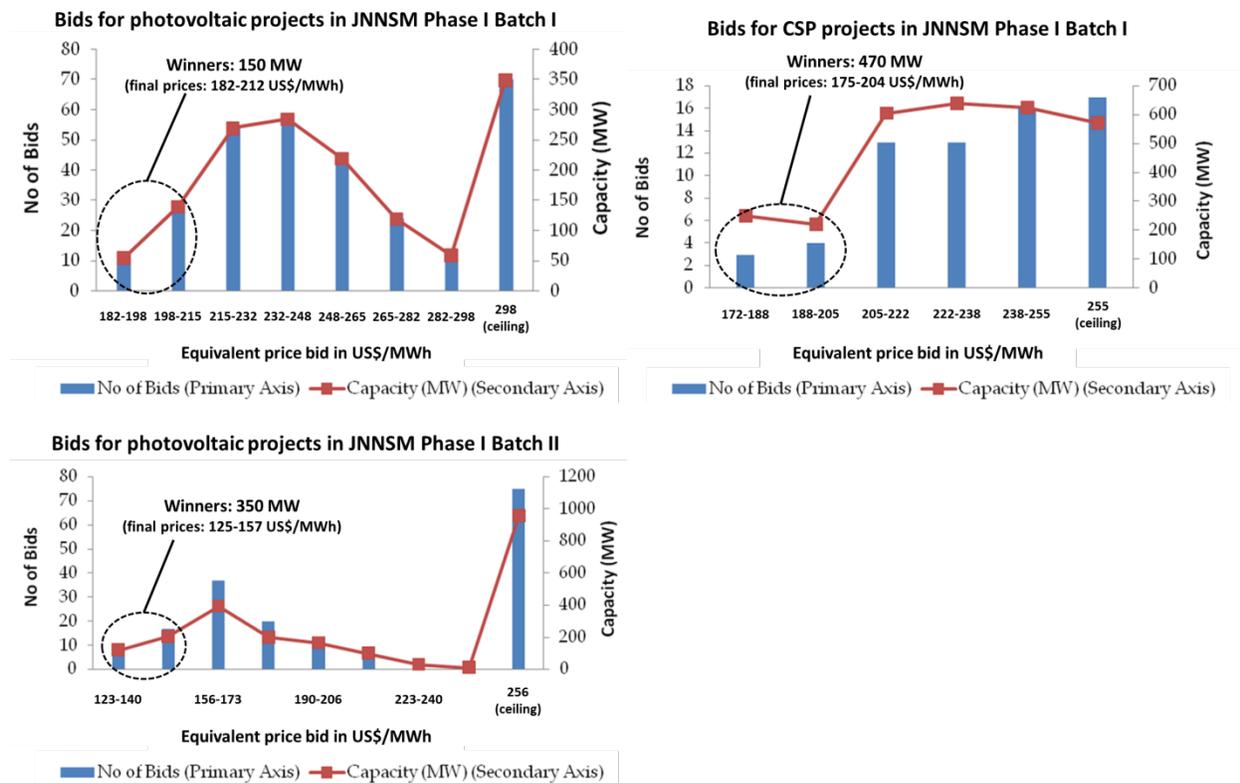
Another more subtle development that occurred between the two NSM phases was a shift in focus away from the CSP technology. While many of the earlier state-level schemes followed the lead of the NSM Phase I auction and foresaw an important role for CSP (including Karnataka and Rajasthan), constraints on construction schedules and/or project size generally prevented their large-scale participation in the auctions. In addition, since the CSP projects that had won the initial auctions had experienced difficulties, the role of CSP in the more recent auctions has been diminished. The importance of rooftop smaller-scale implementations has increased at both the national and state levels.

4.3 Auction Performance

Results from the bidding stage

The NSM Phase I auctions resulted in major price discounts relative to the ceiling, largely due to the strong competition among suppliers – the amount of bids received outnumbered the desired capacity additions by nearly ten to one in the case of PV, and six to one in the case of CSP technology. As a consequence, generally only the bids on the tail end of the distribution have been contracted, as illustrated in 8; which in turn allowed India to procure solar power at extremely competitive prices relative to most worldwide implementations. The fact that these auctioned prices are not subject to any escalation means that the generation will become gradually cheaper in the long term, further benefitting consumers.

Figure 8 – Price bids received in the NSM Phase I auctions¹⁷



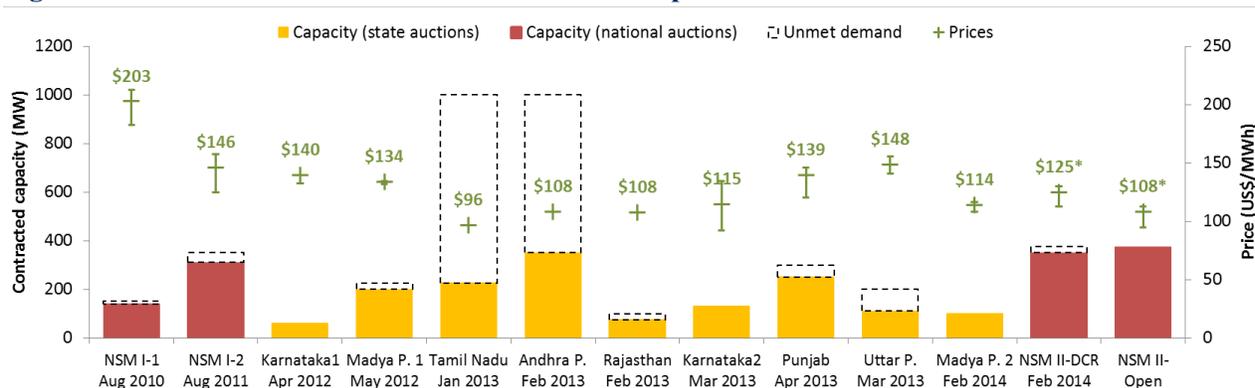
Source: MRNE, 2012, modified by the authors

Over the following years, even lower price bids have been received in the multiple state auctions, as illustrated in Figure 9. Contrary to the NSM auctions, the state auctions were usually not as massively oversubscribed, and many of them have had difficulties in attracting a reasonable number of bidders. The states of Tamil Nadu, Punjab, and Uttar Pradesh did not even receive enough bids to meet the auction demand in its entirety largely due to the poor financial situation of distribution companies in those states, although other elements have also likely played a role (such as high land costs and low irradiation in

¹⁷ For all figures presented in this Chapter, an exchange rate of 60 INR/USD was assumed (representative of the mean exchange rates in the first quarter of 2014). It may be relevant to point out that, at the time the NSM Phase I auctions were carried out, exchange rate was closer to 45 INR/USD.

Punjab; it is also possible that the Uttar Pradesh’s 10-year PPA was perceived negatively by some potential investors). The lower competition led Punjab and Uttar Pradesh to purchase solar power at prices comparable to the NSM Phase I auctions two years earlier, although most other states were able to achieve lower prices (see Figure 9).

Figure 9 – Schematic overview of some of the most important solar PV auctions in India^{18,19,20}



Another element that resulted in some auctions contracting less capacity than was originally intended was the L1 bidding scheme; in Tamil Nadu, Andhra Pradesh, and Rajasthan, multiple bidders declined to sign the PPAs once the lowest bid was made public as they were unwilling to match that price. On the other hand, it is relevant to point out that the L1 bidding scheme seemingly did have an immediate effect in reducing the prices in these three auctions – as Figure 9 shows, these three states were also the ones that ultimately achieved the lowest prices.

The VGF mechanism of the NSM Phase II auctions is more difficult to compare to the other auction prices, due to the different nature of the receivables. We have estimated an “equivalent” levelized tariff as a basis for a comparison with the VGF subsidies including the PPA payments using a very simplified financial model with a 15 percent nominal weighted average cost of capital and an 18 percent average capacity factor over the entire plant’s useful life (i.e. already incorporating degradation effects). While there are significant uncertainties with respect to these parameters, this calculation gives a reasonable initial estimate that confirms the perception that solar power prices have so far maintained a decreasing trend. The Indian government’s choice to separate the NSM Phase II auction demand into a “domestic content requirement” (DCR) portion and an “open” portion resulted in competition being significantly greater in the open portion (86 projects totaling 1470 MW) compared to the DCR portion (36 projects totaling 700 MW); and in a substantial price difference between the two (ca. 15 % in equivalent terms).

In January 2012, the state of Gujarat proposed a revision to the state-level FIT scheme that had been in place since January 2010, due to the substantial reductions in investment costs that had been evidenced by

¹⁸ Auctions with demand smaller than 50 MW have been omitted from this figure (including SECI rooftop auctions and auctions from the state of Odisha).

¹⁹ The Tamil Nadu data depicts the state’s “L1” auction results rather than the results obtained after the state’s “workable tariff” was disclosed later.

²⁰ Due to the very different nature of the auctioned products (such as the shorter 10-year PPA in Uttar Pradesh and the very different schedule of payments implied by the VGF mechanism from the NSM Phase II), several assumptions needed to be made in order to obtain reasonably comparable values for this Figure. For this reason, the auctioned prices listed here should be interpreted only as rough estimates rather than exact values.

the NSM Phase I auction results. Despite this revision, the decrease in the Gujarat FITs established in January 2012 has not been able to keep up with the more substantial price reductions that have been achieved in the auctions.

Construction and generation performance

The very low prices achieved in the Indian solar auctions initially raised concerns on whether the projects would be constructed on time or ultimately profitable. However, the evidence so far suggests that delays have been quite manageable for PV plants in the NSM Phase I auctions – 125 out of 140 MW sold in the August 2010 auction were operational before March 2012; and the entire 310 MW sold in the August 2011 auction was operational in May 2013. The commissioning time allotted was 12 months for the first batch and 13 months for the second batch, starting from the date of PPA's signature (January 2011 for Batch I and early 2012 for Batch II). These figures indicate that delays have rarely been greater than two months; thus we infer that the penalties put in place have largely been sufficient to ensure the timely construction of the projects.

CSP projects, on the other hand, have faced much greater challenges; none of the seven allocated CSP plants were able to meet the auction documents' expected commercial operation date (COD) of early 2013; and more than one year later only one 50 MW plant had been successfully commissioned (Stadelman, 2014). One major difficulty that the project developers faced was that earlier estimates of direct solar irradiation in India which were used in bid preparation were later found to be overestimated. This severely impacted the plants' profitability and made it difficult for investors to secure financing.

Most of the states that implemented auction-based policy schemes have achieved a degree of success; although none so far have been able to rival the scope of Gujarat's more aggressive FIT-based policy. Madhya Pradesh currently has the most successful state-level auction scheme, with 175 MW operational as of March 2014. However, one concern with regards to the state-level implementation is that delays of up to one year have been observed in the schedules of projects sold in the Karnataka, Madhya Pradesh, and Rajasthan solar auctions; the state authorities have been relatively accommodating, extending the deadlines with no penalties or requiring some minor justification. This lenient practice can set a bad precedent, giving investors an extra incentive to be overly aggressive on their planned schedules.

Another obstacle to the swift development of the Indian state-level policies has been the regulatory uncertainty in Tamil Nadu and Andhra Pradesh. Although these two states had originally declared the most ambitious auction-based state-level policies in India, aiming to contract 1,000 MW of new capacity each, policy instability has since severely undermined these two state programs.

In Tamil Nadu, the auctioned "L1" price was substituted by a "workable" tariff determined unilaterally by the state's Energy Development Agency in an effort to attract more suppliers; as a result, the state's Regulatory Commission contested the modification paralyzing the process of signing the PPAs. In Andhra Pradesh, the government issued a decision ex-post to apply a "traditional" L1 bidding scheme, even though the auction documents described a scheme that would allow for price differences between different substations (to take into account differences in irradiation levels and land costs).

Currently expectations for solar capacity expansion in both states are much lower; Andhra Pradesh reduced its official target from 1000 MW to 350 MW. In addition, this instability has likely damaged investors' confidence, which could have negative long-term consequences.

5. THE CASE OF CHINA

5.2 Background

China's experience with the design and deployment of price- and quantity-setting policy instruments to support renewable energy development provides valuable insights on how to design, sequence, and customize different regulatory and market-based mechanisms to develop renewable energy markets. Feed-in tariffs are the cornerstone of the Chinese renewable energy policy framework, while the auctioning of concessions has played the critical role of establishing appropriate feed-in tariff levels.

China is an energy giant. Over the last decade, the country has made extraordinary investments in generation and transmission, more than doubling its installed capacity in just six years (from 519 GW in 2005 to 1,073 GW in 2011) and dramatically expanding access to grid-connected electricity for its 1.3 billion inhabitants. Although China still relies heavily on conventional electricity sources, particularly coal, for its expansion, programs to promote renewable energy have gained increased traction, to the point that the country is currently the world leader in total wind power capacity (75 GW at the end of 2013) and ranks third in total solar photovoltaic capacity (18 GW at end 2013) (REN21 2013). Moreover, China's renewable energy sector has grown very quickly over a short period of time.

The electricity market in China has passed through several stages, evolving from a vertically integrated monopoly to a system in which generation is separated from transmission and distribution. In 2007, the market exhibited a diverse and thriving generation segment, with five large generation groups owning 40 percent of total installed capacity and more than 4,000 smaller generation companies owning the rest. The transmission segment is characterized by large regional monopolies dominated by large grid companies, with the State Grid Corporation accounting for 80 percent of the system. The distribution segment has a complex structure, with more than 3,000 companies at the provincial, prefectural, and county levels, a third of which are affiliated with the two largest grid companies. It is in this context that the renewable energy market has evolved.

The rapid growth of renewable energy in China followed from the 2005 Renewable Energy Law, one of the first in the developing world. The law, which took effect in 2006, set a solid foundation for achieving the ambitious goals of increasing the share of non-fossil fuel generation (including both renewable and nuclear energy) to 15 percent of primary energy supply by 2020. Although the law was initially intended to support the use of a feed-in tariff, key stakeholders could not agree on the tariff level, and an auction-based concession scheme was adopted to establish market-based tariffs.

The aggressive scale-up of renewable energy continued under the 12th Five-Year Plan (2011–15), with special focus on increasing the competitiveness of the renewables industry through a combination of regulatory policies and market-based mechanisms.

The 12th Five-Year Plan laid out eight priority renewable energy programs, with emphasis on (i) planned large-scale wind power bases (each with an installed capacity of 5–10 GW) in the North, Northeast, and Northwest regions; (ii) off-shore wind development; and (iii) large-scale grid-connected solar photovoltaic bases in desert areas. Complementing the large-scale development of grid-connected renewable energy, the plan has also made renewables-based distributed generation a priority, particularly in 100 planned “New Energy Cities” and 200 planned “Green Counties.”

In addition, the National Energy Administration is preparing a decree to set mandatory non-hydro renewable energy quotas for provinces,

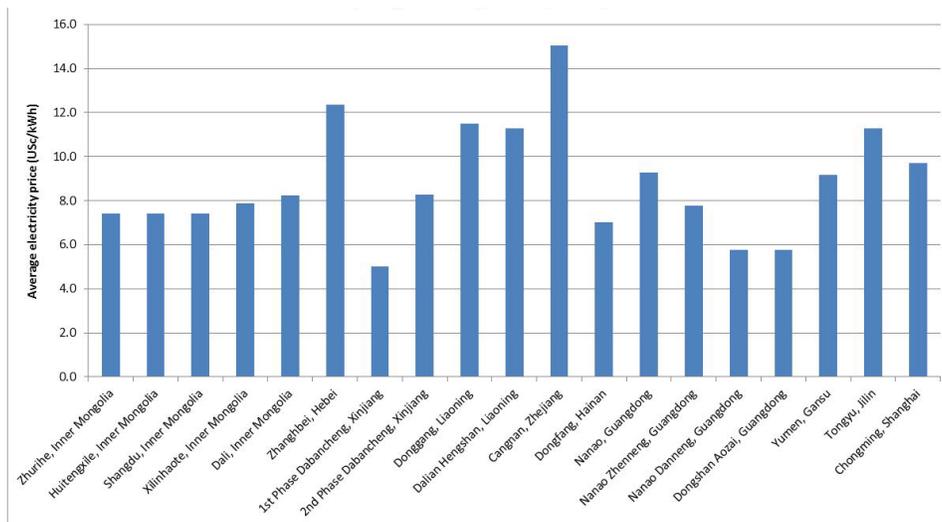
5.2 Early design and objectives

The most important milestone in the development of renewable energy in China was the 2005 Renewable Energy Law, which established a clear roadmap and goals for the development of the industry and cemented the current structure of incentive mechanisms based on auction schemes as a price-discovery mechanism to support the setting of feed-in tariffs.

Introduced partly to respond to growing pressure from the international community to take action to slow climate change, the law was motivated primarily by local environmental concerns and by national industrial development policy.

Before the 2005 law, under the 9th and 10th five-year plans, China had failed to meet official targets for expansion of renewable energy. A first auction to award wind power concessions was organized in 2003. Before that date, a few isolated wind power initiatives had been undertaken at prices set by local governments with a great degree of variation; most of these projects benefited from concessional finance provided by international donors and did not go through international competitive bidding (figure 10). Before the enactment of the 2005 law, it was unclear who would cover the incremental costs between renewable energy and energy generated from fossil fuels.

Figure 10 – Mean electricity prices for wind power generation projects operational at the end of 2006 (before the auctioning of concessions)



Source: Junfeng, Pengfei, and Hu 2010.

In this context, an international bidding scheme was devised as a manner to provide a credible, market-based mechanism to determine the price level, greatly reducing the amount of deliberation involved in the

price determination process. “Auctions”²¹ were thus implemented starting in 2003 for larger-scale projects (100 MW or greater) – while tariffs for smaller projects continued to be defined on a case by case basis; the results of the bidding procedures for larger projects would also influence their price-setting, by offering a price benchmark for wind power.

Not long after the Chinese wind power auction scheme was instituted, the enactment of the Renewable Energy Law called for the definition of national feed-in tariffs to ensure steady capacity additions and adequate remuneration of wind power investors.

With this policy shift, the role of the competitive bidding approach as a price discovery mechanism to support the setting of a nation-wide tariff became even more important. Indeed, the auction mechanism was particularly well-suited for supporting the design of the Chinese FIT scheme due to its inherent characteristics (i.e.; market oriented, driven by competition, transparency in price discovery).

The Chinese auction mechanism involved site-specific bids (sometimes referred as “tendering” or “concession” mechanisms) – although bids for multiple candidate project sites were typically addressed in single auctions (carried out once per year). The wind power auctions were organized by the National Development and Reform Commission (NDRC), and involved two technical teams (a technical group and a business group) that would evaluate the candidate bids over the multiple steps of the process – typically involving pre-qualification, detailed evaluation, ranking of candidates, and negotiation with the bidders. In the early implementations, a simple minimum-price criterion was implemented to select the auction winner.

PPAs were signed for a period of 25 years (after a 3-year commissioning period), with the tariff resulting from the auction applicable only to the first 30,000 full load hours of wind production; the remuneration would then lower to converge with the mean market prices for the remainder of the contract. This payment scheme aimed to provide a strong safety net to investors during the period of loan repayment.

However, the auctioned PPAs did not offer clear rules or penalties for delays and/or operational underperformance, which represented a dangerous incentive for “adventurous” bidding. In addition, a minimum domestic content requirement of 50 percent was mandated.

²¹ While in China these project-specific auctions are generally referred to as concession schemes, in this paper we refer to them as “auctions”.

Mechanism revisions

The most important design innovation introduced in subsequent wind power auctions was the use of multiple criteria to score bidders submissions; in addition to the price, the new criteria included benefits to the local economy and indicators associated with the technical and managerial experience of bidding companies.

The contribution of the price criterion to the final score was reduced to 40 percent in the third wind power auction of 2005, and to 25 percent in the auction that followed in 2006.

In the fifth wind power auction in 2007, the price criterion (still accounting for 25 percent of the bid score) was completely redesigned to benefit the bid closest to the average (after excluding the highest and lowest bids). This average price criterion was introduced with the intention of screening out “wild cards” and discouraging bidders from offering below-market prices.

The “average-price” criterion implemented in the Chinese fifth wind power auction was quite unique and it strongly affected the strategic behavior of bidders, forcing agents to anticipate competitors’ bids in order to gain an edge.

In the fourth wind power auction conducted in 2006, another important innovation was that wind turbine manufacturers were required to participate in the auction as co-bidders²², offering a detailed manufacturing plan for complying with a 70 percent domestic content requirement on wind power equipment (increased from 50 percent in the earlier auctions). The fifth wind power auction in 2007 also introduced rulings that better delineated the responsibilities (bureaucratic and financial) of project developers, the government, and the local transmission company.

With the institution of wind power FITs in 2009, auction schemes were discontinued for that particular technology. However, auctions still remain an important tool in the Chinese policy makers’ toolbox; most recently auction schemes were adopted to support the development of other renewable generation technologies (e.g.; solar photovoltaic (PV) auctions were carried out in 2009 and 2010, and offshore wind power auctions in 2011). The National Energy Administration (NEA) has been designated as the entity responsible for these more recent auctions.

In 2011, a national FIT policy was introduced for PV plants indicating that solar PV has also “outgrown” the auction mechanism. Offshore wind power could also be expected to follow this path eventually.

In general, the offshore wind power auctions implemented a design scheme similar to the 2007 auction for onshore wind, including the requirement that the project developer and turbine manufacturer submit a joint bid, and a multi-criterion selection process which prioritized price bids closer to the average (although price accounted for 55 percent of the score in this case instead of 25 percent). In addition, decommissioning of the offshore wind plant was added to the list of project developer’s responsibilities (although the developer also had the option of maintaining the plant operational and signing a new PPA after the original expiration date). The commissioning time for offshore wind was 4 years.

The solar power auctions, on the other hand, followed a design scheme reminiscent of the wind power auctions of 2003, simply involving the minimum-price winner selection mechanism. Commissioning time for solar PV plants was fixed at 2 years.

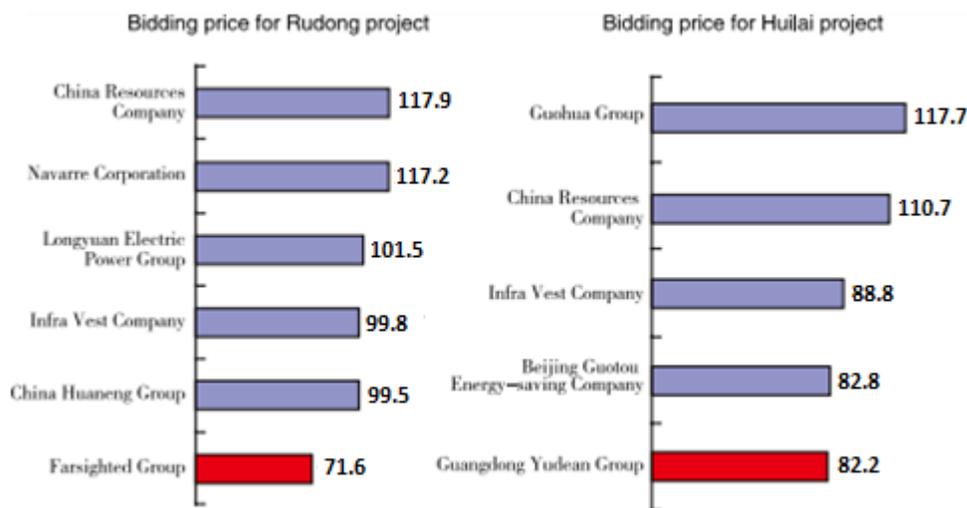
²² The wind turbine manufacturer could also be the single bidder, if it wished to develop the project itself.

5.3 Auction Performance

Results from the bidding stage

Figure 11 shows the bids submitted from various participants in the two wind power projects auctioned in 2003 (Rudong and Huilai, 100 MW each). Competition was relatively strong in this first auction, with at least five bids received for each project²³, enabling significant price reductions from existing baseline. However, Chinese policy makers were concerned with the possibility that these low bids would not conduce to the sustained development of the Chinese renewable energy sector.

Figure 11 – Price bids received in the first round of wind power auctions, in US\$/MWh²⁴



Source: GWEC, 2007, modified by the authors

Indeed, a few of the auction participants submitted aggressive bids, likely prioritizing strategic goals rather than immediate profitability. The Farsighted group, for example, offered a very low bid for the Rudong plant that did not seem compatible with existing feasibility studies, and the following year offered a much higher price -30 percent above- for a project located in the same region (GWEC, 2007).

Thus, in these early bidding processes the resulting prices were lower than the actual costs of production. As a result, some of the contracts awarded were not implemented. This outcome reflected the participation of inexperienced bidders (and the related absence of sufficiently stringent procedures to qualify bidders), as well as the fact that large state-owned enterprises wishing to enter the wind-power business bid very low prices without fear of being outbid, knowing that they could cross-subsidize their wind-power activities from their coal-based generation business. The lower-than-cost bidding prices had the effect of slowing the expansion of wind power in China, sending a wrong market signal and

²³ Competition fluctuated over the following years – some projects in the 2004 and 2005 auctions, for example, received only one or two bids; although in the 2006 auction there were as many as ten bids for some projects

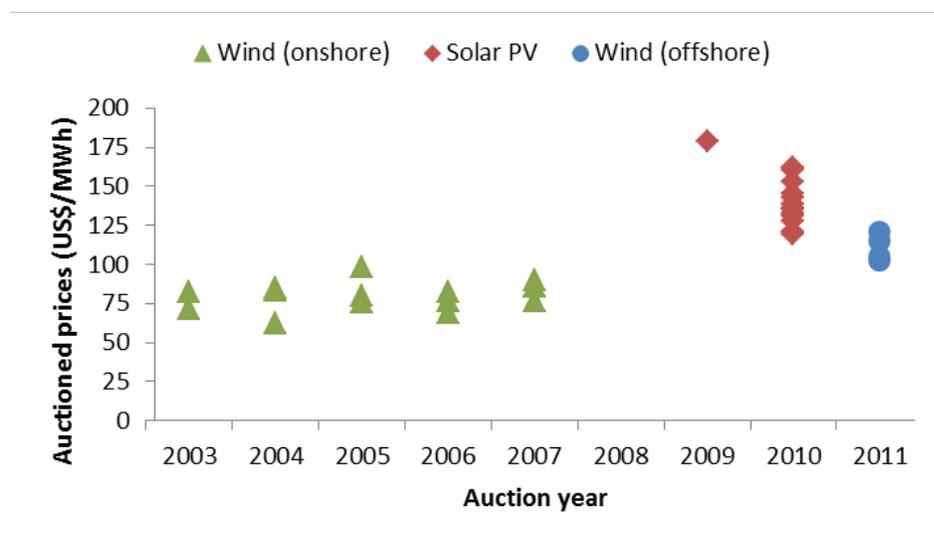
²⁴ For all figures presented in this Chapter, an exchange rate of 6.1 CNY/USD was assumed. It may be relevant to point out that, at the time the 2003 auctions were carried out, exchange rate was closer to 8.3 CNY/USD.

discouraging wind-power developers as well as companies in the supply chain of wind power manufacturing.

The mechanism was then revised to avoid distortions in competition, reducing the weight of the price bid component in the decision criterion, as discussed previously. Despite this measure, however, in most cases the concession was awarded to lowest-price offered by bidders, an indication that while the price component represented a smaller fraction of the decision criterion, it still played a major role in differentiating among competing companies.

This experience eventually led to decision of selecting the price closer to the average (2007 auction). The resulting mean price of the 2007 auction was nearly 12 percent higher than the price of the 2006 auction, as illustrated in Figure 12.

Figure 12 – Summary of auctioned prices for various technologies in China



Source: Prepared by the authors

Even though the prices resulting from the on-shore wind power auctions did not show a clear decreasing trend in the five consecutive tenders (as indicated in Figure 12) -- in part due to difference in the auction design -- prices exhibited a more stable (and on average lower) range than the administrative prices set by local governments shown in Figure 10.

The auctions were effective in revealing costs and establishing cost benchmarks for the setting of more appropriate and economically efficient feed-in tariffs. In 2009, the government issued a “Notice of Improved Feed-in Tariff for Wind,” with geographically differentiated feed-in tariffs in four different regions with varied wind-resource potentials, ranging from 0.51 to 0.61 Y/kWh (≈ 0.07 to 0.09 US\$/kWh).

The development of solar photovoltaic followed a similar path—evolving from concessions to feed-in tariffs.

The 2009 auction for a 10-MW solar plant in Dun Huang received 13 valid bids in the range 113 and 315 US\$/MWh; the winning bid –second lowest in this case- was 179 US\$/MWh²⁵. The 2010 auction awarded 13 solar plants for a total capacity of 280 MW with prices between 119 and 162 US\$/MWh, where the highest price was even 9 percent lower than the lowest price resulting from the previous auction.

The government issued feed-in tariffs for grid-connected solar photovoltaic at 1.0 Y/kWh in 2011 (≈ 0.15 US\$/kWh), based on the concession results, then later moved to lower, geographically differentiated feed-in tariffs in three regions reflecting their solar resource potential. The regional feed-in tariffs ranged from 0.9 to 1.0 Y/kWh in 2013 (≈ 0.15 US\$/kWh).

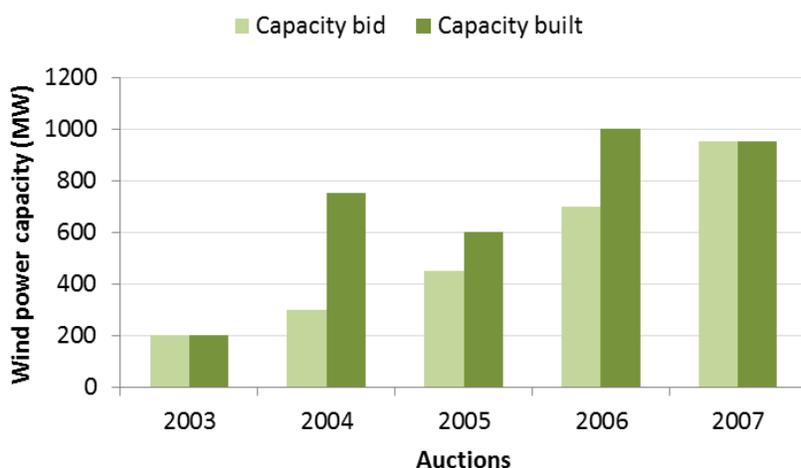
The only auction carried out to deploy offshore wind offered four projects with an aggregated capacity of 1000 MW, and resulted prices in the range of 102-121 US\$/MWh.

Construction and generation performance

Despite the aggressive pricing behavior that has been observed in some of the earlier Chinese wind power auctions, project developers had generally been able to construct the plans in the first few years after the auctions – all of the five wind concessions granted in the 2003 and 2004 auctions, for example, were operational by the end of 2007, with an installed capacity of 550 MW (Pengfei, 2008).

Indeed, in many cases the project developers and the government reached an agreement during the negotiations phase to actually increase the pre-agreed capacities. These increases in installed capacity are illustrated in Figure 13 – in total, the wind concessions directly enabled the development of nearly 3,500 MW of wind power capacity; and indirectly influenced the development of much greater amounts by offering price benchmarks for other applications.

Figure 13 – Auctioned quantities in the Chinese wind power auctions



Source: Prepared by the authors

²⁵ In the local currency, bids were between 0.69 and 1.9 Yuan/kWh; and the winning bid was 1.09 Yuan/kWh.

However, the plant performance in several cases was suboptimal and lower than expectations; for example, the Huilai project sold in the 2003 wind power auction achieved a capacity factor of only 16.9 percent in its first year of operation – nearly 25 percent lower than the estimates from the pre-auction feasibility studies (Pengfei, 2008). While these downside risks are typical of the wind generation activity, the fact that companies had bid very narrow margins in the Chinese auctions in the first place resulted in lower profits. Ultimately, this led several of the auctioned projects to be delayed or cancelled.

The offshore wind projects auctioned in 2011 have been also facing important challenges largely due to the lack of coordination between the auction organizer and the State Oceanic Administration which is responsible for the management of the sea areas (conflicting uses of delimited sea zones reserved for offshore wind projects have resulted in bureaucratic hurdles, ultimately requiring modifications to the siting of original projects). All four projects are currently severely delayed, and the short track record of offshore wind velocity measurements also contributes to the uncertainty regarding the profitability of projects. These unresolved issues have likely been the main reason for no other offshore wind auctions being organized since the first one.

Offshore wind is currently in a less mature stage of development, and it is likely that further bidding processes will be organized before a national FIT is set for this technology. A similar cycle can be expected to be followed by solar CSP.

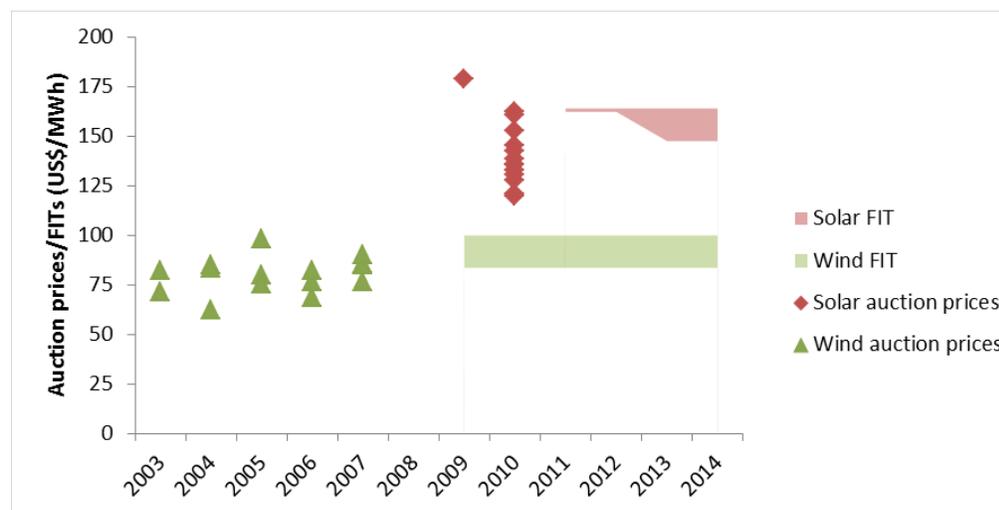
Development of the renewable energy industry

Auctioning of concessions has played an important role in China's scale-up of renewable energy, particularly as a price-discovery mechanism for the determination of feed-in tariffs.

As illustrated in Figure 14, the FIT levels established by the Chinese government²⁶ have been comparable to the average Chinese auctioned prices, and slightly slanted towards the upper end of the price bids. This pricing strategy is more conducive to rapid capacity expansions, since there will be a greater number of potential investors that will be interested in the opportunity; and it is coherent with the Chinese ambitious renewable energy goals.

²⁶ In 2009, the Chinese government established FITs for wind power developments varying by geographical region, in the range between 0.51 and 0.61 yuan/kWh. In 2011, a nationwide FIT for solar power equal to 1.0 yuan/kWh was established – two years later, this tariff was modified to differentiate among geographical regions, varying between 0.9 and 1.0 yuan/kWh.

Figure 14 – Comparison between auctioned prices and feed-in tariffs



Source: Prepared by the authors

The use of auctions for price discovery in China has significantly reduced the likelihood of feed-in tariffs being set above market equilibrium prices, thus avoiding excessive additions of renewable energy capacity and the heavy surcharge on consumers that excess capacity has entailed elsewhere (Elizondo and Barroso 2014). Of course, in China, the risk of excess capacity is mitigated through the country’s very fast load growth and the ease of diluting renewable energy costs in consumers’ electricity bills. Presently, renewable energy costs are passed through to consumers in the form of a surcharge of 0.008 Y/kWh (≈ 0.0013 US\$/kWh).

The chief lesson from China’s experience with auctioning of concessions is that winning bid prices that are lower than actual costs wind up deterring the development of renewable energy. Some of the winning bidders during the first and second rounds of China’s wind-concession auctions were inexperienced players whose goal was to get into the promising wind market first rather than to maximize profits. Some of them did not fully understand the wind-power business, having failed to conduct high-quality feasibility studies and thus lacking sufficient data on the potential of the wind resource. In the later rounds of the wind concessions, large, state-owned power generators dominated the tenders, but their core business was coal-fired power generation, which they used to cross-subsidize the marginal wind business. Even after the government adjusted its criteria for choosing the winners of wind-concession auctions, the winning bids in most cases were still those that had offered the lowest prices. Therefore, careful design of the concession scheme is necessary to ensure the success in the performance of auctions.

China’s policy for the development of renewable energy policy has reflected the country’s specific needs and characteristics (including the size and rapid growth of its energy market). Simply replicating another country’s successful policies with insufficient regard to underlying circumstances is not likely to lead to the most effective choice. The Chinese government is used to regulating prices under its traditional planned economy; in other countries where the government has not refined its price-setting power to the degree seen in China, auctions may be the right choice even if they do not help to perfect a system of efficient feed-in tariffs.

6. CONCLUSIONS

This paper discusses the experience with the use of auction-based mechanisms to support renewable energy in three large emerging economies with an aim to highlight relevant lessons in design of the mechanism and its implementation. The auctions analyzed present important differences in design, which are summarized in the comparative table below.

Table 2 – Comparison of various features of the auction-based policies introduced in Brazil, China and India

	Brazil	India	China
Case study	Wind: ca. 11.7 GW awarded in 10 auctions in 2009-2013	Solar: ca. 2.7 GW awarded in 15 auctions in 2011-2013	Wind: ca. 3.5 GW awarded in 5 auctions in 2003-2007 Solar: ca. 0.3 GW awarded in 2 auctions in 2009-2010
Renewable policy	-No official target for renewable energy -Sporadic technology-specific auctions; fiscal and financial benefits	-NSM target: 20 GW of solar by 2022 -Hybrid policy: RPO-based in the long term, supported by auctions and FITs	-Five-year plans: 200 GW of wind, 50 GW of solar by 2020 -FIT-based core policy
Auction types	Regular auctions and reserve auctions – both centrally organized but differing in allocation of responsibilities	National-level auctions (large-scale and rooftop) and state-level auctions – decentralized implementations	Centralized tenders only, differing by technology type
Main goals of auctions	Exploiting synergies between wind and hydro, correctly assessing wind power's contribution to the system	Main means to procure solar capacity at low costs in the scale-up phase of solar power development	Supporting price discovery mechanism to determine benchmarks for setting feed-in tariffs
Basic auction design	-Technology-neutral or technology-specific auctions -Hybrid price discovery -Inflation-indexed PPA -Clear obligations & penalties	-Technology-specific auction -Sealed bids -PPA without escalation -Clear obligations & penalties	-Project-specific tender for concession sites -Sealed bids -PPA without escalation -Unclear obligations&penalties
Unique design innovations	-Yearly and 4-year settlements to protect investors from wind generation uncertainty -Attempts at G-T coordination	-“L1” pricing in some states -VGF and capital subsidy payment schemes	-Multi-criterion winner selection -“Average-price” criterion
Domestic content	“Indirect” DCR, required to apply for attractive loans from state bank BNDES	DCR not implemented in many state auctions; mixed signaling to manufacturers	DCR of 50-70% was enforced up to 2009. Domestic industry is currently competitive

Source: Prepared by the authors

Choosing the appropriate instrument to promote the development of renewable energy in a particular country hinges on multiple factors, but auction-based schemes are an alternative that policy makers should consider. Auctions appear as an effective way to stimulate competition among investors, provide price disclosure while eliciting the right amount of investment, and offer revenue stability via long-term contracting. It is important, however, that policy makers have a clear understanding of the strengths and weaknesses of various auction schemes.

Auctions offer stable guarantees to both investors and consumers. Auction winners are assured a stable, long-term revenue stream. Consumers have the security of knowing that the right amount of renewable energy capacity will be built. This two-sided benefit of the auction process is especially valuable when there is reason to believe that the environment may be technologically, economically, politically, or institutionally unstable.

Well-designed auction schemes can kick-start a country's renewable energy program. Because organized auction processes tend to attract attention from international players, they can be an interesting alternative for countries in which the energy market lacks a mature renewable energy segment. In fact, this may be one reason why auctions have been popular in emerging economies, where the risk of a few firms exerting too much market power has been a barrier to RPO schemes. The three emerging economies analyzed have exploited the opportunity to develop their domestic capacity to produce renewable energy equipment as well as other supporting industries and services. Although domestic content requirements (DCR) have been challenged in international trade forums, a well-designed auction scheme can take advantage of existing competitive and comparative advantages in the manufacturing of renewable energy equipment and in the provision of services in both domestic and international markets.

Auction mechanisms should be fully integrated with other regulatory, planning, and economic strategies. Auctions do not operate in a vacuum. The interdependence between an auction scheme and a country's regulatory structures and practices can be an asset or a liability to the auction's success. Despite the guarantees that auction mechanisms offer to investors, their success is likely to be limited if they are not supported by an environment of regulatory stability, transparency, and fairness. On the other hand, auction mechanisms that are deeply integrated with a country's energy planning can be very effective in expanding the generation and transmission systems in a coordinated way, for the simple reason that auctions signal what projects are to be built well in advance.

Auction mechanisms can be very effective in reducing prices. In Brazil, China, and India, auction mechanisms have been successful in bringing energy prices down, compared to levelized cost benchmarks calculated on the basis of "reasonable" assumptions (which are generally used to determine an auction's cap price and price levels for FIT programs). In part, the price reductions can be attributed to the development of industries and services that support renewable energy generation, as described above. And, of course, lower energy costs represent gains for consumers. Attracting additional bidders tends to be a more effective strategy for driving prices down than choosing a lower price cap.

Auctions are complex, and transaction costs can be significant. A criticism of auction schemes is that they are significantly more complex and more costly than either FIT or RPO mechanisms. Besides requiring more public resources to design, analyze, and carry out the selection procedure, this complexity (which is the downside of their flexibility) also makes it more difficult for smaller players to participate because it is more difficult for them to dilute transaction costs in their portfolios. The cost of complexity must be kept in mind when considering sophisticated auctions. Brazil's auctions are an example of a high-complexity mechanism that had unforeseen consequences.

Discouraging overoptimistic behavior has been a major challenge of past implementations. Common problems, such as delays in construction and underperformance, have been identified in systems using multiple auctions to foster renewable energy. Although these problems can be dealt with to a degree

by stiffening penalties for failing to meet the original objectives, it does seem that the winning bid too often represents a best-case scenario rather than a reasonable expectation. Policy makers should be aware of this risk and seek to build a mechanism that can accommodate deviations in a robust way. Incentives to provide early warning of potential problems should be built in, so that mitigation measures can be taken at the earliest possible stage.

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