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Reaching India's Renewable Energy Targets: Effective Project Allocation Mechanisms

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Executive Summary

The Government of India has set ambitious renewable energy targets for 2022, in order to achieve its climate goals and enhance energy security. Given India's budget constraints, a cost-effective policy path will be crucial in achieving these targets.[1]

Governments around the world are using auctions more to procure renewable energy.

One way to reduce the cost of government support needed to achieve its renewable energy targets is through the tariffs it uses to procure renewable energy. Federal and regional governments in India have procured renewable energy through two mechanisms: feed-in tariffs, where the government fixes tariffs (i.e., the rate at which electricity is procured) for projects which are allotted on a first-come, first-serve basis, and auctions, where project developers quote tariffs to the government and are selected based on predefined technical and financial criteria. Typically, wind power has been procured through feed-in tariffs, and solar power through auctions.

Auctions for renewable energy are gaining popularity around the world due to their potential as a more cost-effective mechanism for the government. In this context, we examined auctions in India and elsewhere to answer two questions. First, have auctions been effective, or in other words, are they desirable as a project allocation mechanism? Second, how can they be designed to achieve India's renewable energy targets, or in other words, how can they be made feasible?

We found that auctions are almost always cost-effective and have led to fair project allocation in most cases, but so far have not resulted in adequate deployment. We also found that high risk of certain factors can hurt the effectiveness of auctions, but that the right policy designs can lower risk to make auctions more feasible for renewable energy.

Effectiveness

We assessed whether auctions are desirable as a project selection mechanism by examining 20 renewable energy auctions around the world with respect to cost-effectiveness, deployment effectiveness, and the design to encourage market development.

Cost-effectiveness

We define cost-effectiveness as a reduction in tariffs due to auctions when compared with a baseline feed-in tariff. Given that government cost of support is directly proportional to these tariffs, this reduction translates to a reduction in government cost of support. In this context, we also examined whether auctions are discovering tariffs that are close to the rate of renewable electricity that a competitive market would discover,[2] and whether transaction costs impact cost-effectiveness.

Auctions were almost always cost-effective.

Auction-discovered tariffs were almost always lower than the baseline feed-in tariffs for the auctions we studied, meaning they were almost always cost-effective. We observed savings of up to 58% from the baseline feed-in tariff. 47% of the auctions had savings of greater than 20%; 24% had savings of 10-20%; and 29% had savings of up to 10%.

1 For instance, funds allocated to Ministry of New and Renewable Energy (MNRE), were reduced from INR 1,500 Crores in 2013-14 to INR 441 Crores in 2014-15.

2 A price from auctions that is too high means that the auction was not as cost-effective as it could have been, while a price from auctions that is too low increases the risk of non-deployment.

Second, auction-discovered tariffs for solar projects in India have moved closer to market tariffs. Auction-discovered tariffs moved from within 23-35% of competitive tariffs in 2010-2011 to within 1-6% by 2012-2013.

Third, when we looked at whether auctions might lead to increased costs for project developers, we did not find any additional transaction costs when compared with feed-in tariffs. However, developers are concerned about the indirect financing costs due to uncertainty about auction outcomes.

Deployment effectiveness

We define deployment effectiveness as the ability of auctions to deploy the capacity of renewable energy intended through these auctions.

Among the auctions we studied, although some auctions were able to deploy capacity successfully, many were not able to deploy the full intended amount. Only 17% of the auctions had greater than 75% deployment of the capacity auctioned, while 8% had 50-75% deployment, and 75% had less than 25% deployment.

Deployment effectiveness can be improved with better risk management.

Poor risk management is the primary reason for the failure of auctions in deployment effectiveness. Changes to policy design could improve this.

Market development

We define market development as whether an auction ensured high competition and therefore reduced risks to deployment. This would help the long-term development of competitive markets, which would then result in improved market efficiency, including long-term cost-effectiveness, over time.

We found that auctions led to fair allocation of projects in the majority of cases, when policy was designed to encourage high participation and limit allowed capacity per bidder. Among the auctions we examined, around 2/3rds of the auctions were competitive or moderately concentrated, meaning that capacity was allocated to a large number of developers. Capacity allocations in approximately 1/3rd of the auctions were highly concentrated, with a few dominant developers garnering the majority of the capacity auctioned.

Feasibility

We examined how to best design auctions to reach India's renewable energy targets by assessing seven risks which might affect their success. We found that auctions can achieve cost-effectiveness and deployment effectiveness with the right policy design.

Cost-effectiveness is affected most by auction design risk, which is risk related to the design of auctions such as the volume of capacity to be auctioned and type of bidding. In particular, an auction is not cost-effective when there is not enough competition for the capacity auctioned. Controlling the renewable capacity auctioned and encouraging participation from project developers can result in sufficient competition and thus cost-effectiveness.

Deployment effectiveness is most affected by auction design risk, completion risk, which is the risk of all factors that could delay the commissioning of projects, and financial risk, which is the risk of projects not being able to raise finance due to low bid prices or high off-taker risk. We found that auction design risk to deployment effectiveness in terms of underbidding can be best managed by imposing strong penalties for not commissioning the projects. Addressing problems associated with delays in transmission interconnection through support policies for transmission infrastructure expansion, and problems associated with poor financial health of the off-taker through a payment security mechanism, can minimize completion and financial risks.[3]

We also found that it is important to consider both cost-effectiveness and deployment effectiveness together. Designing auctions with the sole objective of cost-effectiveness, as in the case of auctions in which all bidders were asked to match the lowest bid, could negatively affect deployment. Auctions that were balanced in their objectives and managed risks well have demonstrated that both cost and deployment effectiveness can be achieved together.

3 To see individual auctions and how they managed risks, refer to Table 3 in Section 3.

Auctions for wind power

Given significant developer resistance to wind energy auctions in India, we gave special attention to how wind auctions could be designed to meet India's wind energy goals.

In the cases we examined, although wind power auctions have been cost-effective, they did not meet deployment targets due to poor risk management, primarily underbidding risk and completion risk. We suggest mitigating underbidding risk through penalties for not commissioning on time, and completion risk through preemptive measures such as providing regulatory permits prior to holding site-specific auctions.

Policy Implications

Our analysis indicates that, if designed appropriately to manage risks, auctions can deploy renewable energy capacity in a cost-effective and fair manner. The following policy design features would likely make auctions more successful:

- To increase cost-effectiveness, ensure sufficient competition by setting the volume of capacity auctioned well within the market's ability to supply.
- To improve deployment effectiveness, impose strong penalties for delays in commissioning projects, implement support policies to improve transmission infrastructure, and provide government guarantees to reduce off-taker risk.
- Use auction design elements that can mitigate risks to achieve both cost-effectiveness and deployment effectiveness together. For the specific case of wind energy in India, introduce auctions in a controlled environment, in which the project site is already identified, transmission infrastructure is planned, and resource assessment studies are completed prior to bidding.

Contents

1. Auctions for Renewable Energy

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

In India, governments have been using both auctions and feed-in tariffs to procure renewable energy, typically auctions for solar power and feed-in tariffs for wind power. Under feed-in tariffs, governments offer long-term contracts and guaranteed payment for electricity at a fixed rate. Although feed-in tariffs are a popular mechanism, governments may not always have the best information to set the correct, competitive tariff, which can lead to cost inefficiency if too high, or underbidding and non-deployment if too low.

Given India's budget constraints for supporting renewable energy, a cost-effective policy path is crucial to achieving the country's renewable energy targets. Auctions, if designed properly, could help deploy renewable energy capacity in a cost-effective and transparent manner.[4]

However, policymakers in India have raised questions about the ability of auctions to achieve the expected goals and whether auction risks can be properly managed. To assist policymakers in India, we assessed the following two questions:

- Have auctions been effective as a mechanism to procure renewable energy, or in other words, are they desirable?
- How can auctions be designed to achieve India's renewable energy targets, or in other words, how can they be made feasible?

We selected a sample of 20 renewable energy auctions to study in detail. Our criteria for selection were auctions in similar large developing countries as India, auctions that provide sample variation (for example, auctions in developed countries which were perceived to fail or succeed), and auctions with the necessary available data.[5]

Section 2 examines if auctions have been effective as a mechanism to procure renewable energy. Section 3 examines the risks which might affect auctions and how auctions can be designed better to manage risks, with a special focus on auctions for wind power. Section 4 offers recommendations to policymakers.

4 We discuss different types of auctions in Appendix A

5 We applied these criteria on a larger group of 25 auctions to select the most suitable auction programs to study in detail. We listed these auctions in Table 4 in Appendix B.

2. Effectiveness

To assess whether auctions have been effective as a mechanism to procure renewable energy, we examined 20 auctions and measured their success against three objectives:[6]

- Cost-effectiveness
- Deployment effectiveness
- Market development

We consider cost and deployment effectiveness to be primary policy objectives of auctions. However, market development is also important, given that it carries both short-term and long-term implications for deployment and cost-effectiveness.

2.1 Cost Effectiveness

To determine cost-effectiveness, we looked at the weighted average tariff of the winning bids in an auction and compared it with a baseline feed-in tariff. We defined cost-effectiveness as a reduction in the auction tariff when compared with the baseline feed-in tariff.

Our baseline feed-in tariff is the feed-in tariff that was previously used in the same region of the auction or used in a comparable region around the same time.[7]

For example, to measure the tariff reduction achieved through India's National Solar Mission Phase 1 Batch 1 auction (2010), we used the feed-in tariff from Gujarat's Solar PV project (2009), which existed prior to the introduction of the National Solar Mission, as the baseline feed-in tariff.[8]

6 We developed these objectives from discussions with policymakers and other experts, Maurer L. et al., (2011), and MNRE (2012). This research indicated that these are the three main policy objectives for using auctions to procure renewable energy.

7 The ideal baseline is the feed-in tariff that would have been used if the auction were not introduced. Since these do not exist, instead we used a proxy – the feed-in tariff that existed in that country/region or the feed-in tariff that existed in a comparable region around the same time. These tariffs would have continued or adopted in case auctions were not introduced. We acknowledge that this metric is not perfect, especially in the case of solar PV, where tariffs have decreased drastically over the last five years. Our cost-effectiveness results could be somewhat overstating the benefit of auctions.

8 For subsequent state level auctions, we used Central Electricity Regulatory Commission's (CERC) benchmark tariff applicable for that year, as states would have most likely adopted it as their feed-in tariff had auctions not been introduced.

Auctions were almost always cost-effective.

Auction-discovered tariffs were almost always lower than the baseline feed-in tariffs for the 17 auctions we studied.[9] Tariff reductions were up to 58% in the case of solar PV auctions and up to 30% in the case of wind auctions (Figure 1).

Tariff reductions were greater in solar auctions than in wind auctions because solar power has been experiencing significant reductions in capital costs. However, wind power auctions are still an attractive mechanism to achieve cost-effectiveness.

To categorize the success of auctions in cost-effectiveness, we created the following thresholds:[10]

- *Highly successful:* A tariff reduction of more than 20%
- *Successful*: A tariff reduction of 10-20%
- *Somewhat successful*: A tariff reduction of 0-10%

Based on the above scale, 60% of the solar auctions were highly successful, 30% were successful, and 10% were somewhat successful. Among the wind auctions, 29% of the auctions were highly successful, 14% were successful, and 57% were somewhat successful.

We also examined whether auctions are discovering competitive tariffs, or in other words, tariffs that are closer to prices of renewable energy in a competitive market.

Ideally auction-discovered tariffs should be similar to tariffs that would be discovered in a competitive market. Tariffs that are too high are not as cost-effective as they could be; too low and they raise the risk that the winning bidders do not deploy.

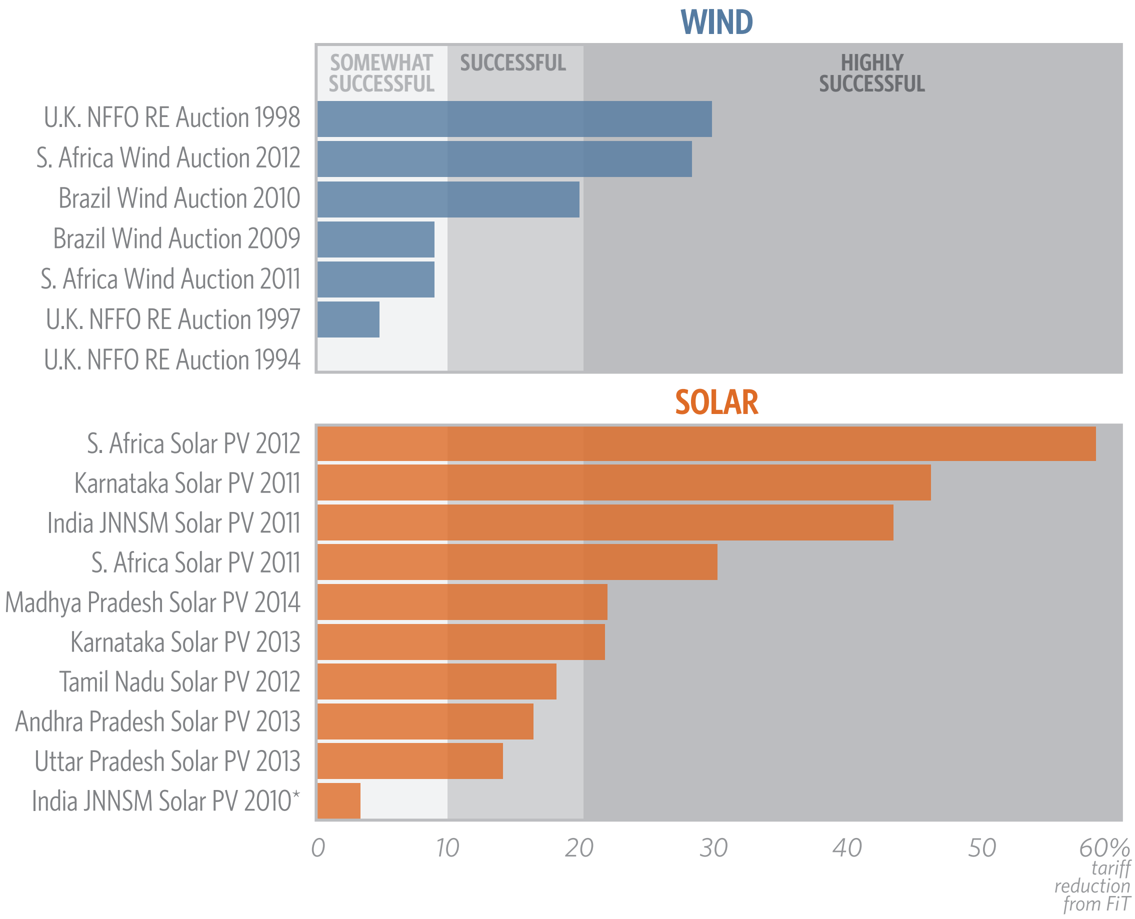
We compared the tariffs from Indian solar power auctions to an estimate of a competitive tariff, which would also indicate if auction-discovered tariffs were tracking reductions in renewable energy costs.[11]

9 Out of the 20 auctions we selected for this work, 3 did not have available data for the baseline feed-in tariff, so we examined 17 auctions.

10 This categorization allowed us to assess the relative performance of auctions with respect to cost and deployment effectiveness and for measuring risks. The categories were created by dividing the range available. We have more categories when the range is large and vice versa. This scale is similar to well-known scales such as the Likert scale (Likert R., 1932).

11 We explain how we estimated the competitive tariff in Appendix C. Our analysis is limited to Indian auctions due to data availability.

Figure 1: Cost-effectiveness of auctions



* Using the Gujarat feed-in tariff as the baseline, the tariff reduction achieved is 3.3%. Using CERC's benchmark tariff as the baseline, the tariff reduction is 32.3%.
Sources: World Bank, GERC, MNRE, Panchabuta, Economic Times, KREDL, Re-Solve, EfficientCarbon, IFC, IRENA, ANEEL, GWEC

In Indian solar power auctions, we found that, while auction-discovered tariffs are lower than competitive tariffs, they have moved closer to the competitive tariffs over the past four years. Auction-discovered tariffs moved from within 23-35% of the competitive tariffs in 2010 to 2011, to within 1-6% in 2012 to 2013 (Figure 2). It appears auctions are dynamically tracking reductions in costs of solar power (which is reflected in competitive tariffs), at least in the case of solar auctions in India.

Although auction-discovered tariffs have moved closer to competitive tariffs, they are still somewhat lower, possibly either because of underbidding by inexperienced players due to a lack of understanding of the true costs (Deshmukh R. et al., 2011)[12] or because CERC improved its estimates of benchmark tariffs over time with more experience, upon which our estimated competitive tariffs largely relied.

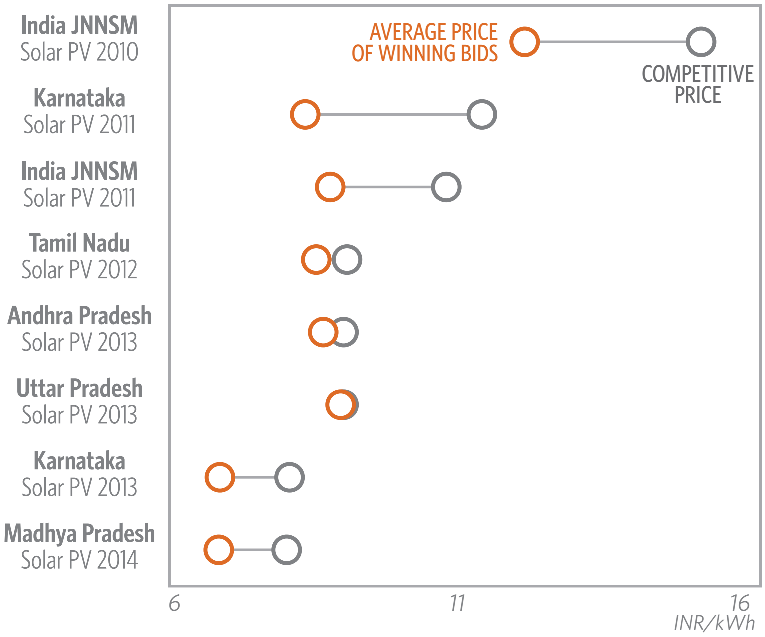
There are no additional evident transaction costs under auctions, but developers are concerned about the costs and risks of business uncertainty.

We also examined whether auctions led to an increase in transaction costs for renewable energy project developers, which would in turn decrease the cost-effectiveness of auctions by increasing the bid prices. In our research and discussions with project developers, we did not systematically find additional tangible transaction costs for auctions when compared with feed-in tariffs.

In fact, in some situations, auctions may actually be less costly than feed-in tariffs, especially for developers who commission projects on time. For example, in the state of Karnataka, commissioning a solar PV plant under Karnataka's auctions is cheaper than under the feed-in tariff policy, with a non-refundable fee of INR 10,000 under auctions compared to a non-refundable fee of INR 1.10 lakh per MW under the feed-in tariff policy (KREDL, 2011 & 2014).

12 Some reports indicate that internal rate of return (IRR) for the projects commissioned under JNNSM Phase 1 Batch 1&2 could be as low as 10% and 12% respectively (Donovan C., 2011).

Figure 2: Auction tariffs vs. competitive tariffs



Source: NVVN, KREDL, UPNEDA, CERC, Efficientcarbon, Re-solve

On the other hand, in the same state, penalties for not commissioning a project on time, which are typically collected up front as security deposits and are refunded when the projects are commissioned on time, are much higher under auctions. These penalties, in the form of various refundable fees, are INR 21.10 lakh per MW under auctions compared with INR 5 lakh per MW under feed-in tariffs.

Despite a lack of evidence of additional transaction costs under auctions, it is important to note that project developers are concerned about the intangible cost of business uncertainty under auctions.[13] Project developers have to incur costs and raise money, but face the uncertainty of not winning a project under auctions. Developers are also subjected to the stop-and-go approach of auctions as they have to wait for the government/procurer to hold auctions at timely intervals.

Some studies indicate that because of these intangible costs, financing costs of projects under auctions could increase compared with projects under feed-in tariffs, due to uncertainty and higher perceived risks for investors (Bloomberg, 2011).

13 Based on our discussions with project developers

2.2 Deployment Effectiveness

Under auctions, the government announces interest in buying a set amount of renewable energy capacity, which is then auctioned to project developers. We define deployment effectiveness as the ability of the winning project developer to deploy the planned capacity under the auction.[14]

To measure deployment effectiveness, we examined the percentage of capacity deployed from the total capacity auctioned, for 12 auctions.[15]

To categorize the success of auctions in deployment effectiveness, we created the following thresholds:

- *High deployment:* Deployment of more than 75% of planned capacity
- *Medium deployment:* Deployment of more than 50-75% of planned capacity
- *Low deployment:* Deployment of less than 50% of planned capacity

Deployment effectiveness was negatively affected by poor risk management.

For the auctions we studied, although some auctions were able to deploy capacity successfully, many were not able to deploy the full intended amount, due to poor risk management.

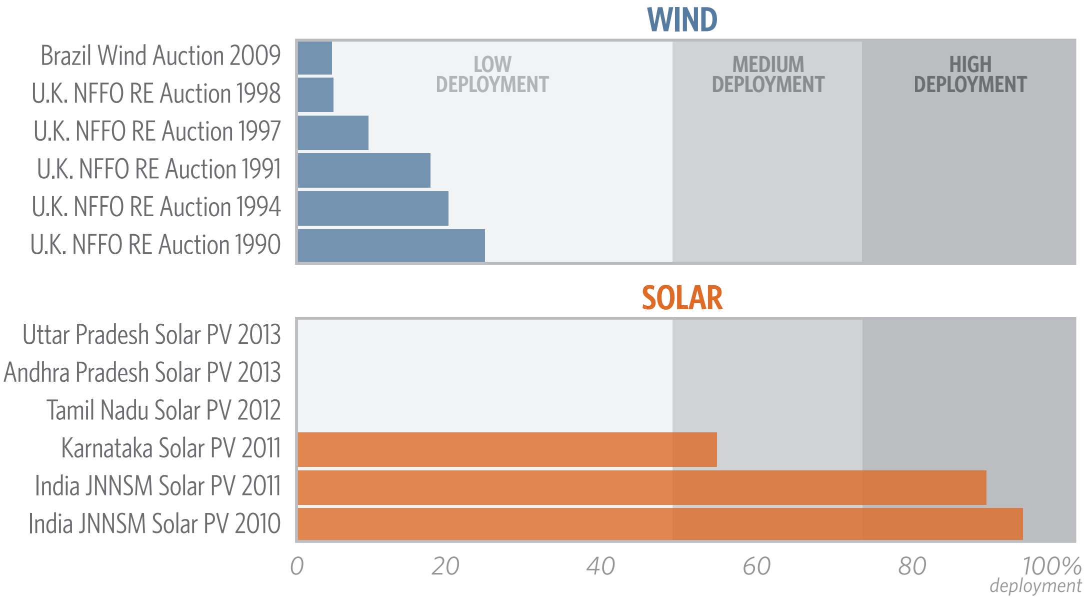
Only 17% of the auctions had high deployment with greater than 75% deployment, while 8% had medium deployment with 50-75% deployment, and 75% had low deployment with less than 50% deployment (Figure 3).[16]

14 We measured deployment achieved by the date of our research, Sept-Oct 2014. The ideal metric is deployment achieved by the commissioning deadline specific to each of the auctions, but there were a number of instances of extension of deadlines and lack of data of commissioned capacity by deadlines. We excluded those auctions that haven't reached their commissioning deadlines (e.g., South Africa) assessment.

15 We looked at 12 of the 20 auctions we initially selected because 8 of the auctions have yet to reach their commission deadlines or have just passed their deadlines but don't have available data yet.

16 This does not include - Karnataka Solar PV Phase 2 (Aug 2013), Madhya Pradesh Solar PV (Jan 2014), Brazil's Wind Phase 2, California's RAM 1&2, and South Africa's Phase 1&2 Wind and Solar auctions -as they are too recent and are yet to reach the deadline for commissioning.

Figure 3: Deployment effectiveness of auctions



Source: MNRE, KREDL, Re-Solve, NEDA, Efficientcarbon, Aneel, Windpowermonthly
Note: All data is as of September 2014, except for the Brazil auctions which is as of August 2012, which is close to the original deadline for commissioning.

Deployment effectiveness was primarily impeded by poor risk management. It is important to note, however, that project risks, which are risks that can affect all procurement mechanisms, affected deployment more than risks specific only to auctions (discussed more in Section 3). This indicates that auctions specifically were not entirely responsible for poor deployment.

This is evident in India as well, where other procurement mechanisms such as feed-in tariffs have experienced poor deployment. For example, Rajasthan's wind power feed-in tariff policy of 2004, which allotted a total of 12,435 MW of projects in 2004-2012, resulted in deployment of only 1,790 MW, or 14% of the total capacity that was allotted (RRECL, 2014). Karnataka also recorded poor deployment effectiveness of 20% under their feed-in tariff policy (KREDL, 2015).

On the other hand, auctions that managed risks well, such as India's JNNSM auctions, were successful in deployment. We discuss this further in Section 3.

2.3 Market Development

Under auctions, governments allocate renewable energy capacity based on the price quoted by project developers, and usually the lowest bidders win. A single large dominant player could place the lowest bid for a project that garners the majority of the capacity auctioned, if no restrictions are in place. This concentration would increase the risk of projects not being commissioned due to developer specific risks, such as bankruptcy.

High competition among bidders and a competitive allocation of planned capacity not only reduce risks to deployment in the short-term, but also help develop a longer-term sustainable market, which requires more than a few large developers in the market. A long-term competitive market results in improved market efficiency, including long-term cost-effectiveness, over time. To measure the fairness and competitiveness of auctions, we used the Herfindahl-Hirschman Index (HHI).[17] We also checked for auction designs such as a cap on capacity per bidder.

17 The HHI index is calculated with the following formula: HHI = S1^2+S2^2+S3^2+......+Sn^2 where S1 is the market share of bidder 1, S2 is the market share of bidder 2 and so on. The resulting HHI number will range from close to zero to 10,000, which indicates low to high market concentration. We used the classification of the U.S. Department of Justice (U.S. Dept. of Justice, 1992) in evaluating the market place with the HHI index.

Table 1: Capacity allocation in auctions

AUCTION	TOTAL CAPACITY AUCTIONED	HHI SCORE	REMARKS	LIMIT PER BIDDER (MW)	LIMIT PER PROJECT (MW)
JNNSM BATCH 1 PHASE 1 SOLAR PV (DEC 2010)	150	333	Competitive	5	5
KARNATAKA SOLAR PV PHASE 1 (OCT 2011)	50	1,411	Moderately concentrated	10	10
JNNSM BATCH 2 PHASE 1 SOLAR PV (DEC 2011)	350	661	Competitive	50	20
TAMIL NADU PHASE 1 SOLAR PV (DEC 2012)	1,000	271	Competitive	No limit	No limit
UTTAR PRADESH SOLAR PV (MAR 2013)	200	2,189	Highly concentrated	50	50
KARNATAKA SOLAR PV PHASE 2 (AUG 2013)	130	828	Competitive	10	10
MADHYA PRADESH SOLAR PV (JAN 2014)	100	2,050	Highly concentrated	No limit	No limit
BRAZIL WIND AUCTIONS PHASE 1 (DEC 2009)	13,341	2,802	Highly concentrated	No info	No info
S. AFRICA WIND AUCTION PHASE 1 (2011)	1,850	1,682	Moderately concentrated	No limit	140
S. AFRICA WIND AUCTION PHASE 2 (2012)	650	1,871	Highly concentrated	No limit	140
S. AFRICA SOLAR PV AUCTION PHASE 1 (2011)	1,450	1,230	Moderately concentrated	No limit	75
S. AFRICA SOLAR PV AUCTION PHASE 2 (2012)	450	1,543	Moderately concentrated	No limit	75

Source: MNRE, KREDL, Re-Solve, NEDA, Efficientcarbon, ANEEL, Eskom, Windpowermonthly

Auctions led to fair allocation of projects in the majority of cases.

We found that auctions led to fair allocation of projects in the majority of cases, when policy was designed to encourage high participation and limit allowed capacity per bidder. Among the 12 auctions we examined, around 2/3rds of the auctions were competitive or moderately concentrated, meaning that capacity was allocated to a large number of developers. Approximately 1/3rd of the auctions were highly concentrated, with a few dominant developers garnering the majority of the capacity auctioned (Table 1).

Auctions designed to allocate capacity to multiple players, such as through a limit on capacity per bidder, would likely improve cost-effectiveness by encouraging competition, as well as increase deployment effectiveness by diversifying developer-specific risks, such as bankruptcy of the developer, which can lead to delayed or abandoned projects

Some of the auctions we examined included a limit on capacity per project instead of a limit per bidder and some both.[18] A cap on capacity per project would ensure that high volume of capacity is not concentrated at any one geographic location, which could burden the transmission network.

18 Auctions that included limit on capacity per bidder were successful in allocating capacity in a competitive manner, for example, the Indian Solar PV auctions of National Solar Mission and Karnataka. Auctions such as Madhya Pradesh and South African solar and wind auctions, which did not include a limit on capacity per bidder, resulted in concentrated capacity allocations.

3. Feasibility

The second question we examined was: how can auctions be designed to achieve India's renewable energy targets, or in other words, how can they be made feasible?

We analyzed whether auctions can be a feasible mechanism for reaching India's renewable energy targets by identifying risks which might affect their success. We identified several risk factors which can affect all renewable energy projects, as well as risk factors which are specific to auctions, and combined them into seven individual risks (Table 2).[19] We also categorized them as auction-specific risks or project risks to assess which category of risks affects auctions the most.

We assessed the impact of these risks by rating the intensity of each one and examining the effect of each risk on cost and deployment effectiveness.[20] We provide detailed definitions of these risks and how we measured the intensity of each of these risks in Appendix D.

3.1 Total Risk

Total risk, which is the combination of all seven individual risks, has a negative impact on both cost and deployment effectiveness, as expected. [21]

Although we found that an increase in total risk results in lower cost-effectiveness, we would need more data for statistically significant results.

Our findings were more conclusive for deployment effectiveness. We found that for every 1% increase in total risk, deployment effectiveness decreased by nearly 2 percentage points.[22] This underscores the need for increased focus on risk reduction to ensure deployment.

3.2 Project risks vs. auction specific risks

Project risks had a higher impact on deployment effectiveness than auction-specific risks.

Between the risks which affect all renewable energy projects (project risks) and risks which affect only auctions (auction-specific risks), we found that project risks had a greater effect (see Table 2).

We found that project risks did not significantly impact cost-effectiveness. On the other hand, we found that project risks have approximately 60% greater negative impact than auction-specific risks on deployment effectiveness. This indicates that policymakers should focus more on project risks to ensure deployment.

3.3 Individual risks

Cost-effectiveness is most affected by auction design risk.

Among all the risks that affected the cost-effectiveness of auctions, we found that auction design, and specifically when the design did not encourage enough competition for the capacity auctioned, was the only risk that had a statistically significant impact.[23] For example, in South Africa's solar power auctions, where the auction design risk was high, the tariff reduction was only 30%. In comparison, an auction with low auction design risk recorded a tariff reduction of 58%.

19 We categorized into seven individual risks to enable statistical analysis, which requires the number of dependent variables - i.e., the number of auctions in our study - to be considerably higher than the number of independent variables - i.e., risks.

20 We rated each of the seven identified risks on a scale of one to three, with one representing a low intensity risk, two medium, and three representing the highest intensity for each of the auctions we examined. We arrived at these ratings from discussions with project developers and researchers and through literature review. We then examined the effect of these risks on cost and deployment effectiveness via correlation matrix (Goodman and Kruskal Gamma) and regression analysis. We followed a three-step statistical approach for this analysis; first, we measured the impact of total risk, second, we measured the impact of risk categories - auction-specific and project; and third, we measured the impact of each individual risk. We combined this statistical analysis with in-depth qualitative analysis to arrive at our findings.

21 Total risk is the sum of quantitative values assigned to individual risks based on intensity.

22 A percentage point refers to absolute change from the reference value. For example, a reduction in deployment effectiveness from 20% to 18% is a 2 percentage point decrease and a 10% decrease.

23 Another factor that likely played a role in cost-effectiveness is market timing. An example of market timing driving tariff reductions would be the Indian national solar auctions, which were introduced at a time (2010-11) when solar module prices in the global market were declining due to slow-down in demand in key economies (World Bank, 2013). Several state solar auctions quickly followed the national auctions to benefit from the slump in global module prices and the experience gained in the national auctions. However, we would not consider market timing as an auction design element as timing of auctions would be an extremely difficult exercise for policymakers.

Table 2: Risks for renewable energy projects under auctions

RISK FACTOR	RISKS	RISK CATEGORY
Flawed tariff determination (L1 process*)	**Auction design (Risks related to the design of auctions)**	Auction-specific (Risks that arise out of the auction process)
Lack of competition		
Favoring a specific technology (technology neutral auctions**)		
Contract re-negotiations		
Aggressive and unrealistic bids by developers to win projects	**Underbidding**	
Lack of tariff reduction due to cartelization of bidders	**Collusion**	
Delay in land acquisition	**Completion (Includes all factors that could delay the commissioning of the projects)**	Project (Risks that are generally faced by all renewable energy projects and are common with other procurement mechanisms, such as feed-in tariffs)
Delay in environmental and other regulatory permits		
Delay in transmission interconnection		
Projects not able to achieve financial closure	**Financial**	
Payment default by procurer	**Off-taker risk**	
Lack of accurate resource data (Resource risk)	**Technology**	
Plant underperformance		

*L1 process: In this context, a process where the auctioneer asks all the selected bidders to commission projects at the lowest tariff discovered.

** In technology neutral auctions, a procurer does not specify capacity targets for each technology, but allows competition among different energy technologies. This design benefits matured and cheaper technologies.

We found that this risk can be reduced if policymakers ensure more competition by auctioning a volume of capacity which is well within the market's ability to supply. For example, in auctions in South Africa, this strategy resulted in an additional 28 percentage point reduction in auction-discovered tariffs compared to the baseline feed-in tariff. In Phase 1 of South Africa's Wind and Solar Auctions, there was no cap on the volume of capacity auctioned, which led to less competition and a tariff reduction of 30%. In Phase 2, the volume of capacity auctioned was limited, which led to more competition and a greater tariff reduction of 58% (Eberhard A., et al. 2014).

Deployment effectiveness is most affected by auction design risk, completion risk, and financial risk.

Auction design, specifically with respect to flawed tariff determination, has impacted deployment effectiveness. For example, in the Indian Solar PV auctions of Tamil Nadu Phase 1 (Dec 2012) and Andhra Pradesh (Feb 2013) , under the auction design, selected bidders were asked to match the lowest bid in order to sign a contract (Economic Times, 2012 and Re-Solve, 2013). This forced bidders with different cost structures to accept the lowest bid and commission the projects at a loss, which led to poor deployment.

On the other hand, Karnataka, a neighboring state of Tamil Nadu and Andhra Pradesh, used a pay-as-bid type of tariff determination, which resulted in much higher capacity deployment (Figure 3). Pay-as-bid tariffs allow developers to commission projects at tariffs that they determine, if they win a project.

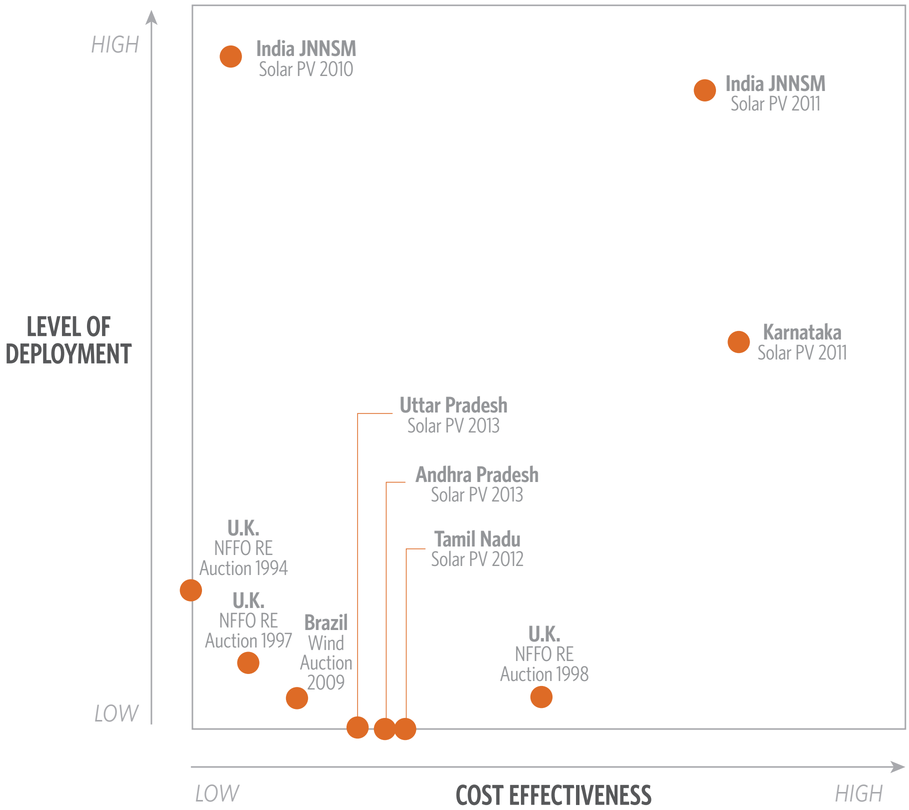
Second, completion risk, such as delays in obtaining environmental and other regulatory permits and lack of transmissions interconnection, has also affected deployment effectiveness. Delays in obtaining regulatory permits negatively affected deployment in the U.K. NFFO auctions (Mitchell C., et al. 2004). Likewise, delays in issuing environmental permits and lack of transmission interconnection (both completion risks) affected capacity deployment in Brazil wind auctions (Cunha G., et al., 2012).

Completion risks such as delays in regulatory permits and transmission interconnection can be managed through both auction design elements and support policies. Specifically, in the case of renewables, which are location-constrained, transmission planning should be conducted before the auction or coincide with it (Madrigal M. et al., 2011).

A third risk that affected deployment effectiveness is financial risk, which is the risk of projects not being able to raise finance or attain financial closure. Financial risk impacted capacity deployment in the U.K. NFFO wind auctions, and Tamil Nadu Phase 1 (Dec 2012), Andhra Pradesh (Feb 2013), and Uttar Pradesh (Mar 2013) solar PV auctions. Financial risk for the U.K. NFFO projects was high because developers placed bids lower than actual costs to win projects (C. Mitchell, 2004). In the case of the Tamil Nadu and Uttar Pradesh auctions, high off-taker risk coupled with a lack of any payment guarantee mechanism increased their financial risk (Business Line, 2013).

A payment guarantee mechanism could help mitigate financial risk, especially if the procurer is not financially healthy. One of the drivers of high deployment in India's JNNSM solar power auctions was the presence of a payment guarantee mechanism, which made power purchase contracts under this auction more bankable (World Bank, 2013). Underbidding risk, the risk of low, unrealistic bids by bidders just to win a project, can also affect deployment effectiveness. In the case of the U.K. NFFO auctions, the lack of penalties for delays in commissioning projects encouraged risky and unrealistic bids in order to win projects (Mitchell C., et al. 2004). The U.K. NFFO auctions were some of the first auctions to be held for renewable energy and lacked design elements to counter underbidding risk.

Figure 4: Cost-effectiveness vs. deployment



Learning from the failure of the U.K. NFFO auctions, all the subsequent auctions we studied used penalties to counter underbidding risk. Auctions such as JNNSM Phase 1 were successful in deploying capacity partly due to inclusion of strong penalties for delaying or not commissioning the projects. This suggests that policymakers should continue to use penalties for failure to commission projects on time to ensure deployment effectiveness.

3.4 Achieving both cost and deployment effectiveness

Policymakers have concerns about whether high tariff reductions achieved in auctions could lead to deployment failure, due to underbidding and, therefore, low returns to investors that ultimately make the projects financially unviable. This was evident in the U.K. NFFO auctions, in which many developers underbid and eventually failed to commission their projects.

We examined ten auctions, for which we have both cost and deployment data, to determine whether there is tension between cost and deployment effectiveness. As shown earlier, while almost all the auctions were cost-effective, only a few were effective in both cost and deployment (Figure 4).

However, high cost-effectiveness need not be always a result of underbidding. Our analysis indicates that deployment failure in many of the auctions was independent of the tariff reductions.[24]

As stated earlier, flawed auction design with respect to tariff determination method, lack of penalties, and payment security mechanisms (when off-taker risk was high), as well as lack of support policies for transmission infrastructure development led to poor deployment.

With proper risk management, both cost and deployment effectiveness can be achieved together.

Auctions that are designed well with respect to managing risks have achieved success in both cost and deployment effectiveness; for example, JNNSM Solar Phase 1 Batch 1 and 2 and Karnataka Solar Phase 1. In Table 3, we highlight how various risk factors were managed through specific design elements in some of the auctions.

24 We did not find a statistically significant and negative relationship between cost and deployment effectiveness.

Table 3: Design elements to manage risks in renewable energy auctions

INDIVIDUAL RISKS	RISK FACTORS	LIKELY IMPACT ON AUCTION EFFECTIVENESS	DESIGN ELEMENTS TO MANAGE THE RISKS	EXAMPLES OF AUCTIONS WHICH USED THESE ELEMENTS
Auction design	Flawed tariff determination (e.g., L1 process*)	Impacts deployment effectiveness as L1 process will force developers other than the lowest bidder to commission projects at a loss	Pay-as-bid instead of L1 process of tariff determination	All the auctions except Tamil Nadu Phase 1 Solar PV and Andhra Pradesh Solar PV
	Lack of competition	Impacts cost-effectiveness of auctions	Limit on capacity auctioned	All auctions except South Africa Wind and Solar Phase 1
	Favoring a specific technology (technology neutral auctions)	Impacts the deployment of new technologies as matured technology would be more competitive	Technology-specific auctions	All auctions except Brazil Wind Phase 1&2 and California RAM 1&2
	Contract re-negotiations	Impacts cost and deployment effectiveness as developers seek higher tariff and negotiate for new power purchase contracts	Non-negotiable power purchase contracts In-built flexibility in PPAs allowing surplus and shortfall in production to be set-off in 4-year block periods	South Africa Wind and Solar Phase 1&2 Brazil Wind auctions Phase 1&2
Underbidding	Aggressive and unrealistic bids by non-serious bidders	Impacts deployment effectiveness due to financial unviability	Penalties for failure to commission projects	All the auctions except U.K. NFFO auctions
Collusion	Lack of tariff reduction	Impacts cost-effectiveness as bidders collude to keep tariffs higher	Ensure high competition and adopt sealed-bid auction	Most of the auctions used sealed-bid auctions except Brazil Wind Phase 1&2, which used descending clock auction.
Completion risk	Delay in environmental and other regulatory permits	Impacts deployment effectiveness	1) Pre-bid environmental license requirement, 2) Procurer/Govt. handles these risks	1) Brazil Wind Phase 1&2 and South Africa Wind and Solar Phase 1&2, 2) India's coal Ultra Mega Power Plant auctions
	Delay in transmission interconnection	Impacts deployment effectiveness	Pre-bid grid access studies	India JNNSM Phase 1, Brazil Wind Phase 1&2, South Africa Wind and Solar Phase 1&2
Technology risk	1) Lack of accurate resource data 2) Resource variability	1) Impacts production of already commissioned plant as developers lack prior knowledge of the resource, 2) Impacts revenues if quantity of resource falls short of the expected quantity stated in the contract	1) Certified pre-bid ground resource studies, 2) Weather derivatives/insurance	1) Brazil Wind Phase 1&2, South Africa Wind and Solar Phase 1&2, 2) None of the auctions we examined had these as part of the auction design, but individual developers may have utilized these instruments.
Financial risk	Projects not able to achieve financial closure	Impacts deployment effectiveness due to financial unviability of projects	1) Pre-bid financial criteria, 2) Concessional finance, and 3) Financial underwriting of bids	1) Almost all auctions, 2) Brazil Wind Phase 1&2, and 3) South Africa Wind and Solar Phase 1&2
Off-taker/counterparty risk	Payment default by procurer	Impacts the financial viability of a commissioned project	1) A sovereign guarantee providing payment security in case off-taker payment default; 2) Centralized procurement through a financially strong off-taker and re-sale to regional utilities	1) India JNNSM Phase 1 Batch 1 PV, South Africa Wind and Solar Phase 1&2; 2)India JNNSM Phase 1, Brazil Wind Phase 1&2, South Africa Wind and Solar Phase 1&2

Auctions that have been successful in both cost and deployment effectiveness used design elements such as penalties for failure to commission projects to manage underbidding risk. These auctions also ensured the presence of high competition to drive cost-effectiveness. In addition, other project risks such as off-taker risk were addressed through a payment guarantee mechanism to ensure deployment. Managing both auction-specific and project risks effectively ensured that these auctions achieved both cost and deployment effectiveness together.

It is also important to note that despite the use of certain design elements, some auctions have failed to achieve cost and deployment effectiveness due to the inadequacy of those design elements. In the case of Brazil wind energy auctions, although the auctions included design elements to handle completion risks (Table 3), they were only designed to partially manage these risks. For instance, environmental permits in Brazil are obtained through a complex three-phase process, which can cause delays, and the auction design only required the first-phase permit as a prerequisite to bid (G. Cunha, et al., 2012).

Therefore, auctions should not only include risk mitigating design elements, but also ensure that those design elements are effective. Further research is required to determine to improve the effectiveness of risk mitigating design elements.

3.5 Designing effective wind power auctions

Wind developers in India fear higher completion and technology risks under auctions.

Given significant developer resistance to wind energy auctions in India, we gave special attention to assessing the feasibility of wind auctions. From our discussions with wind project developers in India, we learned that they were concerned that completion and technology risks, which are generally higher for wind power compared with solar power, would increase further under auctions.

Our research indicates that these concerns are valid to a certain extent. Completion risk, specifically delays in land acquisition and lack of transmission interconnection, could affect commissioning projects on time. Land acquisition is a problem in India due to small landholdings and lack of land purchase options (Market Line, 2014). This means dealing with multiple small landowners and higher upfront land costs.

Another completion risk, transmission interconnection, may also be exacerbated under auctions, as wind resources are not as well dispersed as solar resources in India. Holding a nationwide wind auction would most likely lead to a concentration of wind farms in high wind zones. This may require building new transmission lines or increasing the capacity of existing network, which could lead to completion delays.

In addition, technology risk, which in this context means high resource variability coupled with a lack of conclusive resource assessments for India can present a greater challenge to wind projects than solar projects (Phadke A. et al., 2011).

Wind power auctions in other countries, as well as coal auctions in India, can demonstrate valuable lessons in risk management.

Wind power auctions in the U.K., Brazil, and South Africa, as well as coal-power auctions in India, have shown that flawed auction design and high completion risk can lead to a failure in deployment.

South Africa's wind power auctions, similar to the U.K. and Brazil wind power auctions, did not include comprehensive policy support for building a transmission network to connect the expected new wind capacity, which prevented completed projects from connecting to the grid on time (Eberhard A., 2014).

In India coal auctions, to mitigate the high completion risks associated with large power projects, India adopted Case-2 type bidding for coal Ultra Mega Power Projects (UMPP), where the government bears the risk of land acquisition and other regulatory permits (MoP, 2007). However, even with Case-2 type bidding, the first round of coal UMPP projects have yet to witness success in terms of deployment. Out of the four projects that were allotted, only one project, Mundra, has been able to commission all the units so far, albeit with a delay. The delays in commissioning the projects were largely due to developers seeking contract re-negotiation, due to a change in imported coal prices from Indonesia, and to a government delay in procuring land and permits (Business Line, 2011; Economic Times, 2013). These problems could occur in potential wind power auctions as well.

Wind auctions can be introduced in a controlled environment to address concerns over risks.

Given these concerns and evidence from other countries that wind auctions can lead to inadequate deployment, wind project developers have opposed attempts to introduce auctions for procurement of wind power in India. However, due to the possibility of a higher cost of support under feed-in tariff mechanism, auctions are worth considering, but they should be introduced cautiously and in a controlled environment. We suggest the following steps:

1. To counter underbidding, an auction-specific risk, strong penalties for not commissioning projects should be included, and perhaps bids could be completely underwritten by debt and equity investors as a prerequisite, as in the case of the South African wind and solar auctions (Table 4).
2. For handling project risks such as delays in land acquisition, transmission interconnection, and resource assessment (technology risk), as a transition path, the government can bear the risk of land acquisition and other regulatory permits. Given the problems being faced in the execution of the coal UMPP projects, which were auctioned under a similar model, we suggest land acquisition and other regulatory permits be obtained before auctions are held.
3. The government could hold a location-specific auction once it identifies the land. Identifying the land prior to auctions would give adequate time for developers to undertake resource assessment studies. The government should also require that on-ground resource assessment studies by developers and certified production estimates by an independent evaluator be completed prior to bidding, as in the case of the Brazil Wind auctions (Table 3).
4. To reduce the risk of variability in wind power production (another technology risk), [25] a design feature that allows squaring off excess production with shortfalls over four-year blocks would likely reduce the burden of penalties for variation in power production, as in the Brazil wind auctions (Table 3).
5. To reduce the risk of contract renegotiation owing to changes in fuel prices (for example, in the coal UMPP auctions), which is similar to what could happen for wind power due to poor wind resource assessment, prior identification of land and a prerequisite of resource assessment would likely help. This may be combined with other design features, such as contractual flexibility in carrying forward gains and losses in production and non-negotiable power purchase agreements (used in the South Africa wind and solar auctions).

It is important to note that the above suggestions are meant to apply to interim auctions, which would act as a transition mechanism from the current feed-in tariff based procurement to an auctions-based procurement for wind power in India. Further research is required for designing full-fledged auctions for wind power.

25 Due to high variability in wind power production, developers may not be comfortable to place bids for tariffs that would be applicable for long-term (20-25 years), given the expected high penalties for variations in power production and reduced profit margins under highly competitive auctions.

4. Conclusion

Auctions as a procurement mechanism for renewable energy have been cost-effective and fair in allocation in most cases, but so far have not resulted in adequate deployment, primarily due to poor risk management.

By analyzing the risks which can affect auctions, we found that changes to the design of auctions could enable them to adequately deploy renewable energy capacity, in a cost-effective and fair manner. We recommend the following changes which may help facilitate successful auctions:

- To increase cost-effectiveness, which is affected most by auction design risk, ensure high competition by setting the volume of capacity auctioned well within the market's ability to supply.
- To improve deployment effectiveness, which is most affected by completion and financial risks:
    - » Use support policies to improve transmission infrastructure.
    - » Provide payment guarantees to reduce off-taker risk.
    - » Use a pay-as-bid type of tariff determination instead of forcing selected bidders to match the lowest bid.
- For further improvement of deployment effectiveness, which is also affected by underbidding risk, include stringent penalties for delays in commissioning of projects.
- For the specific case of wind energy in India, start with auctions in a controlled environment, in which the project site is identified, transmission infrastructure is planned, and resource assessment studies are completed prior to bidding.

Areas for future work include examining the effectiveness of risk mitigation design elements and how they could be improved; and the feasibility and design of full-fledged wind power auctions in India.

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6. Appendix

A. Types of auctions

Auctions are a method of procuring a service or a product, in which the government or any other procurer issues a call for tenders to purchase a pre-decided quantity of a services or goods. Electricity auctions are usually 'reverse auctions' meaning that the procurer typically states a benchmark price for the electricity to be procured and the bidders are asked to bid-down the price to be able to win the projects. The government selects the projects based on the price and/or other criteria and signs a power purchase agreement (PPA) for a specific period of time.

Reverse auction mechanism reverses the structure of a typical (forward) auction, where multiple buyers bid to buy something from a single seller to multiple sellers (project developers) bidding to sell something (in this case electricity) to a single buyer. Typically, reverse auctions are used to install a specific quantity of generating capacity unlike projects commissioned under feed-in tariff mechanism - another popular mechanism that is open-ended and designed to install as much capacity as possible that can be built economically at the specified price.[26]

While auctions have long been widely used for procurement of electricity by governments worldwide, the design of auctions continues to evolve depending on the governments' objectives. Historically, governments were using uniform first-price auctions for electricity procurement until the introduction of discriminatory or pay-as-bid auctions in 2001 in England and Wales (Natalia, et al., 2002). Since then, governments have been experimenting with auction designs, leading to the introduction of different types of auctions.

While there could be various ways to classify the types of auctions, we classify the auctions based on their price determination technique. The following are the main types of auctions and their characteristics:

Uniform price auctions

In a uniform price auction, all the successful bidders will receive payment at a single market-clearing price, which is the price at which supply equals demand. Some of the popular auction mechanisms such as sealed bid auctions and descending clock auctions use the uniform price method for allocating projects. While some of the auction mechanisms such as the descending clock auctions enable price discovery as part of their auction process, a few others such as the sealed-bid auctions do not allow price discovery. Regardless, in both auction types, the winners receive a uniform price.

Discriminatory price auctions

In discriminatory price auctions, for example pay-as-bid and some hybrid auctions, the winners of the auction receive the price they bid, resulting in different prices. Discriminatory price auctions are typically used when there are multiple units of the same product to be allocated such as in electricity procurement.

In the usual pay-as-bid sealed bid auctions, the auctioneer gathers all the bids to create a supply curve and then matches the bids with the quantity to be procured. All the bidders who have bid below the market-clearing price will be the winners of the auction. The winners will receive different prices according to the bids they submitted that fall below the clearing price.

Two-sided auction

In two-sided auctions, both supply and demand resources actively participate in an auction, allowing both bids and asks. A transaction will be created when the bid and ask prices match. In contrast, one-sided auctions such as the ones discussed above, only bids are allowed and the winner is usually the one who bids the highest or lowest, as in the case of reverse auctions.

B. Research and data

We used both primary and secondary research techniques to collect data and information. For our primary research, we interviewed project developers, policymakers in India and other experts/researchers who studied energy auctions earlier.

Our questionnaire (Appendix E) for policymakers and experts aims to gather information on the objectives of holding auctions, metrics to be used for measuring success/failure of auctions, and aspects of the design of auctions related to ceiling tariffs, ensuring competition, and the necessary qualification criteria to overcome the risks.

Our questionnaire for project developers (Appendix E) was designed to understand the perspective of project developers on energy auctions vis-à-vis other prominent mechanisms such as the feed-in tariff. We posed

26 Governments are also experimenting with a limit on the capacity installation per year under feed-in tariff mechanism to avoid excessive capacity installation. Recently, the only major difference between the feed-in tariff mechanism and auctions has been the tariff determination method.

Table 4: Selection of auctions

AUCTION PROGRAM	SIMILAR COUNTRY AS INDIA	VARIATION - SUCCESS (S)/ FAILURE (F)*	DATA AVAILABILITY	SELECTED FOR OVERALL FURTHER STUDY - 20 AUCTIONS	SELECTED FOR COST-EFFECTIVENESS ANALYSIS - 17 AUCTIONS	SELECTED FOR DEPLOYMENT EFFECTIVENESS ANALYSIS - 12 AUCTIONS
India JNNSM Phase 1 Batch 1 (Dec 2010)	Yes	Yes (S)	Yes	Yes	Yes	Yes
Karnataka Solar PV Phase 1 (Oct 2011)	Yes	Yes (S)	Yes	Yes	Yes	Yes
India JNNSM Phase 1 Batch 2 (Dec 2011)	Yes	Yes (S)	Yes	Yes	Yes	Yes
Tamil Nadu Solar PV Phase 1 (Dec 2012)	Yes	Yes (F)	Yes	Yes	Yes	Yes
Andhra Pradesh Solar PV (Feb 2013)	Yes	Yes (F)	Yes	Yes	Yes	Yes
Uttar Pradesh Solar PV (Mar 2013)	Yes	Yes (F)	Yes	Yes	Yes	Yes
Bihar Solar PV (Jul 2013)	Yes	Yes (F)	No	No	No	No
Karnataka Solar PV Phase 2 (Aug 2013)	Yes	Yes (S)	Yes	Yes	Yes	No (Too early - commissioning data not available)
Madhya Pradesh Solar PV (Jan 2014)	Yes	Yes (S)	Yes	Yes	Yes	No (Too early - commissioning data not available)
UK NFFO-1 (1990)	No	Yes (F)	Yes	Yes	No (lack of comparable FIT)	Yes
UK NFFO-2 (1991)	No	Yes (F)	Yes	Yes	No (lack of comparable FIT)	Yes
UK NFFO-3 (1994)	No	Yes (F)	Yes	Yes	Yes	Yes
UK NFFO-4 (1997)	No	Yes (F)	Yes	Yes	Yes	Yes
UK NFFO-4 (1998)	No	Yes (F)	Yes	Yes	Yes	Yes
Peru Wind (2009)	Yes	Yes (S)	No	No	No	No
Peru Solar PV (2009)	Yes	Yes (S)	No	No	No	No
Brazil Wind Phase 1 (Dec 2009)	Yes	Yes (F)	Yes	Yes	Yes	Yes
Brazil Wind Phase 2 (Aug 2010)	Yes	Yes (S)	Yes	Yes	Yes	No (Data not available)
California RAM 1 & 2 (Nov 2011 & Apr 2012)	No	Yes (S)	Yes	Yes	No (lack of comparable FIT)	No (Too early - commissioning data not available)
Morocco Wind Phase 1 (2011)	Yes	Yes (S)	No	No	No	No
Morocco Solar (2012)	Yes	NA	No	No	No	No
S. Africa Wind Phase 1 (2011)	Yes	Yes (F)	Yes	Yes	Yes	No (Too early - commissioning data not available)
S. Africa Solar PV Phase 1 (2011)	Yes	Yes (F)	Yes	Yes	Yes	No (Too early - commissioning data not available)
S. Africa Wind Phase 2 (2012)	Yes	Yes (S)	Yes	Yes	Yes	No (deadline for commissioning is around Apr 2015)
S. Africa Solar Phase 2 (2012)	Yes	Yes (S)	Yes	Yes	Yes	No (deadline for commissioning is around Apr 2015)

questions to learn whether auctions provide correct investment signals for all sources of energy and for what reasons. In addition, we also enquired if there are any additional costs and risks for project developers under auctions compared to the feed-in tariff mechanism.

We also undertook extensive secondary research of available literature, some of which we discuss in Appendix F.

Auctions sample

To measure the performance of auctions against the objectives of cost-effectiveness, deployment effectiveness, and market development, we selected a sample of renewable energy auctions to study in detail.

Our primary sources for data on these auctions were government departments and agencies such as ANEEL (Brazilian Electricity Regulatory Agency), California Public Utilities Commission, National Renewable Energy Laboratory (U.S.), Osinergmin (Peru's Energy and Mining Investment Supervisory Body), and Ministry of New and Renewable Energy (MNRE), India. In addition, we also sourced information from private groups, such as publications from International Finance Corporation (IFC), International Renewable Energy Agency (IRENA), World Bank, and individual researchers.

Our criteria for selecting these auctions are:

1. Auctions in similar large developing countries
2. Auctions that provide variation in the sample – e.g., auctions in developed countries or auctions which were perceived to be failure or successful in popular literature
3. Data availability

We applied these criteria to a larger group of auctions (Table 4) to select the most suitable auction programs to study in detail.

C. Assumptions for competitive price calculation

We used our in-house LCOE models to estimate the competitive prices for auctions studied based on the following assumptions:

- Most of the data points such as CUF (19%), useful life (25 years), working capital requirements (Payables: 45 days, Receivables: 60 days), taxes, debt-equity ratio (70:30), and interest rate (in the range of 12.30-13.39%) were taken from CERC's benchmark tariff orders applicable for that year.
- We have taken capital cost (which is in the range of INR 6.91-13.70 Cr./MW over the years) closer to the date of commissioning i.e., we considered one-year forward prices as solar PV projects typically take 12 months to be built. Developers also usually bid with one-year forward expected prices.
- CERC's return on equity (ROE) appeared to be high at 22% when compared with our primary research findings. We have taken ROE (in the range of 16.99-17.25%) based on primary research and data from the PDD documents filed with the UNFCCC by the developers.

D. Measurement of individual risks

Auction design risk: Includes risks related to the design of auctions, such as lack of competition, flawed tariff determination etc. This risk may overlap with the other two auction-specific risks: underbidding and collusion. However, auction design risk goes significantly beyond underbidding and has some uniqueness to be considered separately. We rated the intensity of auction design risk based on literature review and discussions with industry stakeholders.

Underbidding: This includes risks related to the risk of underbidding involved in an auction. For Indian auctions, for which we have bid-level data, we measured the presence of underbidding by examining the distance of the average bid from our estimated competitive tariff. If the average bid was lower in the range of INR 0-1/kWh, we rated it as 1, indicating less risk. Similarly, an average tariff lower in the range of INR 1-2/kWh was rated 2 and in the range of INR 2-3/kWh was rated 3.

It is important to note that not every bid below the competitive tariff may have been an underbid. Bidders may have different cost structures or may have availed concessional finance, which allow them to bid lower than the normal market cost.

Collusion: We aimed to measure collusion among bidders by calculating standard deviation of bids from the average bid, with the assumption that higher the concentration of bids, the more likely it is that there was collusion among bidders. If the standard deviation is in the range of 0-1, we ranked the risk intensity as

3 indicating high chances of collusion. A standard deviation in the range of 1-2 was ranked 2 and in the range of 2-3 was ranked 1 indicating low risk of collusion.

Completion risk: Includes all factors that could delay the commissioning of the projects. For example, delays in land acquisition, environmental and regulatory permits, and transmission interconnection. We have rated the intensity based on literature review and discussions with industry stakeholders.

Financial risk: Derives its value from several factors such as the bid placed, off-taker risk, developer credit-worthiness, technology (wind or solar), or presence of any specific design element such as payment security mechanisms etc. As we don't have information on all the factors that influence the financial closure, we primarily based financial risk intensity on bid placed (underbidding or not) and off-taker risk. However, the value assigned to financial risk is a synthesis of different risks that goes significantly beyond the summation of underbidding and off-taker risk.

Off-taker risk: Off-taker risk is especially applicable in the case of Indian state auctions where the procurers are state distribution utilities, the majority of which suffer from poor financial health. To measure this risk, we used the state utilities rankings by India's credit rating agencies.[27] Auctions for which the procurer was rated A+ and A, we have given a risk intensity of 1 indicating low off-taker risk. Similarly, for B+ we have given 2 and B, C+, and C we have given 3, indicating high off-taker risk.

Technology risk: For renewable energy auctions, technology risk is predominantly the risk of reliability of resource assessment studies. This risk is somewhat high for Indian auctions compared with auctions in other countries due to lack of accurate on-ground resource assessment data.

E. Questionnaires

Questionnaire for policymakers and experts

OBJECTIVES OF AUCTIONS

1. What are the objectives of holding (reverse) auctions?

a) Price reduction/discovery?
b) (Timely) capacity deployment?
c) Meeting budget caps?
d) Fairness in allocation?
e) Others?

27 Ratings by Investment information and Credit Rating Agency (ICRA), Credit Rating Information Service of India Limited (CRISIL), and Credit Analysis and Research (CARE).

MEASURING SUCCESS/FAILURE OF AUCTIONS

2. How do you define success with respect to (reverse) auctions mechanism?

a) Price reduction from benchmark price?
- How would you pick the benchmark price, and why?
- How much price reduction will be considered a success, and why?

b) Capacity deployed as a % of total capacity auctioned?
- Commissioned capacity?
- Capacity online after X years?
- What would be the thresholds (% capacity, X, etc.), and why?

c) Others?

3. How do we measure drawbacks of (reverse) auctions?

a) Underbidding/ winner's curse that could lead to deployment failure
b) Collusion among bidders to prevent price reduction
c) Inequity in terms of a lot of capacity going to a few developers?
d) Others?

4. Are project delays magnified under (reverse) auctions compared with FIT mechanisms? Why?

5. How do we separate the non-auction factors from (reverse) auction design in determining the success or failure of auctions?

a) Price reduction: auctions vs.
- Reduction in capital expenditure (e.g., panel prices)
- Reduction due to provision of concessional finance
- Others?

b) Capacity deployment: auctions vs. failure to deploy expected capacity due to
- Transmission constraints
- Delays in resource assessment/procurement
- Delays in land acquisition
- Delays in getting permits

c) Others?

6. Auctions introduce a large chunk of power generation capacity into the system around the same time unlike the FIT mechanism.

a) Is the bottleneck in transmission capacity a common problem for large energy capacity auctions?
b) Do auctions cause transmission constraints or the systemic problem of lack of transmission that creates problems for auctions?

DESIGN OF AUCTIONS

7. There are several types of (reverse) auction mechanisms. Which auction would you use, and why?

a) Single round – e.g., sealed bid
- Sealed-bid, lowest-price (also known as L1): the N winners are paid the lowest bid
- Sealed-bid, pay-as-you-bid (as used in JNNSM): the N winners are paid what they bid

b) Multiple rounds – e.g., descending clock auction (for price discovery): the N winners are paid the market-clearing price

c) Hybrid auctions – combination of the above two

d) Others?

8. What factors come into play when deciding the timelines for projects in auctions, and why?

a) Capacity deployment target deadlines?

b) Based on existing projects' construction timeline?

c) Based on technology maturity?

d) Based on availability of supporting infrastructure, such as transmission lines, resources – land and water (e.g., for CSP)?

e) Others?

9. Is setting the ceiling price for reverse auctions necessary? Why?

a) Does this provide an indication – similar to multiple round auctions – of where the market could be?

b) Wouldn't bidders gather around the ceiling price, and defeat the rationale – i.e., price reduction – behind reverse auction?

c) Others?

10. How can policymakers ensure high level of participation in (reverse) auctions?

a) Reasonably high ceiling price?

b) Limiting the capacity auctioned?

c) Less stringent pre-qualification/penalty criteria?

d) Others?

11. What design elements should reverse auctions have to reduce the chances of underbidding, leading to deployment issues?

a) Technical pre-qualification to ensure non-serious bidders do not enter?

b) Bid bond?

c) Project completion bond?

d) Penalties for poor performance of the project?

e) Others?

12. How do policymakers strike a balance between having robust qualification criteria and ensuring high competition?

13. Beyond penalties, how can auctions ensure that capacity is deployed on time? (What should the government do vs. what should the developers do?)

a) Ensuring that transmission interconnection would not be a problem

b) Ensuring that land acquisition is not a problem

c) Ensuring that resource assessment is not a problem

d) Others?

14. What are some of the ways that can be adopted to limit the chances of collusion among bidders in auctions?

a) Single round sealed bid auctions?

b) Holding auctions infrequently?

c) Increasing competition?

d) Others?

15.

16. How can fairness in allocation of projects be guaranteed in auctions?

a) Capping the number of projects or volumes that can be bid by a particular bidder?

b) Adopting an auction design that does not favor any particular type of players such as – foreign, state-owned, or private players?

c) Others?

Questionnaire for project developers

[NOTE: Please compare with FIT where appropriate]

1. Do auctions provide the correct investment signals?

a) For conventional power?

b) For all renewable technologies?

c) For specific renewable technology?

d) Others (please specify)?

2. If yes, why?

a) Clear and predictable capacity targets?

b) Market prices ensuring no retroactive price cuts?

c) Fairness in allocation?

d) Transparency in allocation?

e) Others (please specify)?

3. If not, why?

a) Using auctions for new technologies that have uncertain technology costs?

b) Allowing non-serious/non-capable players that could engage in price war?

c) High competition leading to lower margins?

d) Low benchmark prices?

e) High time pressure due to discrete and chunky occurrence?

f) Lack of supporting policies, such as permitting and grid interconnection?

g) Lack of supporting resources, such as land and water?

h) Lack of supporting infrastructure such as transmission capacity?

i) Others (please specify)?

4. Do you incur additional transaction costs in auctions compared with projects allocated under FIT mechanism?

a) If yes, what are they?

- Dealing with pre-qualification criteria?
- Dealing with bid-bonds?
- Dealing with performance-bonds?
- Legal fee (other than above)?
- Advisory fee (other than above – e.g., for bidding strategies)?
- Others (please specify)?

b) Do these additional costs really matter? Why and how?

5. Is cost of financing (i.e., equity or debt) higher under auctions? Why?

6. What are main risks of using auctions for energy procurement? Why?

a) Underbidding leading to low returns and eventual non-deployment?

b) Aggressive timelines leading to higher construction/commissioning risk?

- Procurement of resources a-priori – e.g., land, water, etc. – leading to stranded assets in case of losing?
- Accurate resource assessment (e.g., for wind or solar), which may go to waste in case of losing?
- Inability to get transmission interconnection?
- Others (please specify)?

c) Others (please specify)?

7. In what way each of the risks identified above can be handled better?

a) Stringent qualification criteria – technical and financial -- to avoid underbidding? What should it be?

b) Prior acquisition of land?

- Is it possible to acquire options to buy land?
- Does maintaining land banks help?
- Should the government help – why and how?

c) Undertaking resource assessment studies before bidding? Should the government help – why and how?

d) Ensuring feasibility of transmission interconnection? Should the government help – why and how?

e) Others?

8. It appears that there is a general perception in India that auctions/ competitive bidding for wind power wouldn't work. (However, the solar auctions seem to have worked.)

a) Do you agree?

- If yes, what are the reasons?
- If no, what are the reasons?

b) Are there technology-specific risks for auctions? What are they?

9. Would you prefer auction designs that allow price discovery over those that wouldn't? (For e.g., multiple round descending clock auctions over single round sealed-bid auctions?)

a) Why would you prefer one to the other?

b) In what circumstances your preferences would change?

F. Prior work

Previously a number of individual researchers and organizations have studied the use of auctions for renewable energy procurement globally. Some of these studies had a similar agenda of examining whether auctions have resulted in achieving the stated policy objectives. We discuss a few of these studies, their approach, and findings in this section. A full list of literature that we reviewed is presented in the References section.

In Kreycik C., Couture T., and Cory K. (2011), the authors evaluate procurement strategies such as feed-in tariffs and auctions on four criteria – pricing, complexity and efficiency of the process, impacts on developers' access to markets, and ability to compliment utility decision-making processes. These criteria were chosen to take into account the perspective of each group of stakeholders viz., end-use power consumers, regulators, distribution companies, investors, and developers.

The paper identifies the advantages and disadvantages of the different procurement mechanisms and advises governments to make an informed choice given the policy objectives.

Maurer L. and Barroso L., 2011 discusses efficient practices in electricity auctions in general and renewable auctions specifically. The report focuses on the lessons learned and experiences from both developed and developing countries. Countries/regions examined include: Brazil, Chile, Peru, Mexico, Vietnam, Philippines, Europe, and North America. The authors conclude that, if auctions are successfully designed and implemented, they may lead to far superior results than other procurement mechanisms.

Becker B. and Fischer D., 2012 compares the FIT mechanism with Auctions for renewable energy procurement with the experience in three emerging countries viz., China, India, and South Africa. The paper highlights the importance of policy objectives on policy choice and design. The authors conclude that India and South Africa could achieve their capacity targets in a cost-effective manner using auctions.

Cozzi P., 2012: The author assesses the success and failure of reverse auctions for renewable energy with case studies on U.K., China, and Brazil. The author identifies "success" and "failure" so far as possible with regards to the goals of those implementing the policy.

Conti M., 2012: The paper outlines how reverse auctions work in practice and arrives at conclusions based on outcomes from three case studies: California, Brazil, and Texas.

IRENA, 2013 analyses the design of renewable energy auctions in selected developing countries viz., Brazil, China, Morocco, Peru, and South Africa. The authors qualitatively determine the success and failure of auctions in these countries. The authors also discuss the role of design elements such as the type of auction, ceiling prices, auction volumes, administrative procedures, and guarantees and penalties in determining the success or failure of auctions.