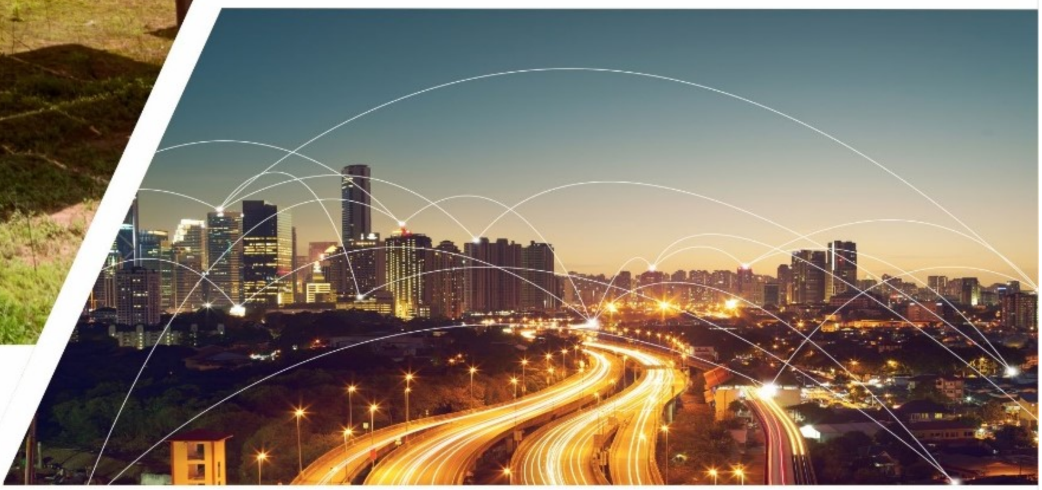
SYSTEM-FRIENDLY COMPETITIVE RENEWABLE ENERGY PROCUREMENT IN INDIA

WHITE PAPER



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SYSTEM-FRIENDLY COMPETITIVE PROCUREMENT FOR RENEWABLE ENERGY IN INDIA

White Paper

Prepared for:

Energy and Infrastructure Office
US Agency for International Development
1300 Pennsylvania Ave, NW
Washington, DC 20523

MESSAGE

The Ministry of New and Renewable Energy (MNRE), Government of India has been making a determined effort in realizing the goal of 175 GW of renewable energy by 2022. India has already become a leading market for renewable energy (RE) in the world- creating a vibrant ecosystem for various stakeholders including business, investors and civil society. Recognizing the need for resilient RE to allow for smoother grid integration and higher capacity utilization, Wind-Solar Hybrid projects are central to MNRE's drive for RE development in India

India and the United States of America have fostered longstanding relationships in the energy sector. The U.S. Agency for International Development (USAID) and MNRE have successfully concluded a six-year bilateral technical assistance program "Partnership to Advance Clean Energy Deployment (PACE-D)" in 2018. Building on the success of PACE-D, USAID and MNRE launched the second phase of the program "PACE-D 2.0 RE" designed to help states take advantage of the economic, environmental and technical/systemic benefits offered by RE, prepare Discoms for the transition to a new energy paradigm and improve markets for private sector investments in RE technologies.

One important global trend has been the increasing use of auctions, as policymakers seek to procure renewables-based electricity at the lowest price while fulfilling other objectives. Right from the start, India adopted auctions in its strategy for the National Solar Missions and expanded it to other RE technologies- leading to record-breaking low prices for solar and wind. Leading RE countries including India are focusing on the design of auctions to achieve objectives beyond the least cost of RE generation, through Solar Wind Hybrids, Round-the-Clock, RE with energy storage to drive the cost of RE to the system.

One of the key elements of the PACE-D 2.0 RE program is to support the development of an apparatus to promote the "system-friendly" RE procurement in India. In this context, this white paper titled "System-friendly competitive procurement for renewable energy in India" developed under the PACE-D 2.0 RE program is timely. The paper captures global experiences in successful large-scale RE procurement designs such as time-based incentives and penalties, aggregators or virtual hybrids, procurement of (physical) hybrid solutions and locational signals. The paper also highlights the challenges surrounding RE procurement in India and offers suggestions for the way forward.

The insights provided in the paper will support the central and the state-level RE procurement agencies in designing RE procurement guidelines that are aligned with MNRE's objective of promoting system friendly solar-wind hybrid projects.

Amitesh K. Sinha
Joint Secretary
Ministry of New and Renewable Energy

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USAID PACE-D 2.0 RE Team

Anurag Mishra, USAID Program Manager
Kristen Madler, Clean Energy Coordinator
Sarah Lawson, Senior Energy Specialist, Energy and Infrastructure Office

Principal Authors

Fabian Wigand
Ana Amazo Blanco

Contributing Authors

Dr. Ujjwal Bhattacharjee
Dr. Rakesh Kumar Goyal
Devina Anand
Arai Monteforte

Editor

Wynne Cougill
Veleka Burrell

CONTENTS

ACRONYMS

BNEF	Bloomberg New Energy Finance
BSES	BSES Rajdhani Power Limited
CBIP	Central Board of Irrigation and Power
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CHP	Combined-heat-and-power
CNE	Comisión Nacional de Energía
CUF	Capacity Utilization Factors
DAM	Day-ahead Market
DISCOM	Distribution Company
DMRC	Delhi Metro Rail Corporation
GERC	Gujarat Electricity Regulatory Commission
GW	Gigawatt
IEA	International Energy Agency
IEX	Indian Energy Exchange Limited
INR	Indian Rupee
IRENA	International Renewable Energy Agency
MNRE	Ministry of New and Renewable Energy
MW	Megawatt
NREL	National Renewable Energy Laboratory
NTPC	National Thermal Power Corporation
PACE-D	Partnership to Advance Clean Energy Deployment
POSOCO	Power System Operation Corporation Limited
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable Energy
RPO	Renewable Purchase Obligation
SECI	Solar Energy Corporation of India
TERI	The Energy Resources Institute India
TPDDL	Tata Power Delhi (North Delhi Power Supplier)
UK	United Kingdom
US	United States
USAID	US Agency for International Development
USD	US Dollar
VPP	Virtual Power Plant

EXECUTIVE SUMMARY

India needs to auction approximately 40 GW of solar and wind capacity every year to meet its renewable energy (RE) target of 40% of total installed capacity by 2030. Rapid decreases in RE costs have allowed India to contract RE generation at prices as low as 2.50 INR/kWh (3.60 cents/kWh) for solar in 2019, 2.51 INR/kWh (3.61 cents/kWh) for wind in 2018, and 2.69 INR/kWh (3.87 cents/kWh) for wind-solar hybrids in 2019. However, while the proportion of RE grows in power systems, system integration challenges and associated costs emerge gradually. A study by the Central Electricity Authority (CEA) estimates that grid integration costs were almost 1.5 INR/kWh (2.16 cents/kWh) in 2017 in states like Tamil Nadu and Gujarat, or more than half of recent RE bids prices.

System-friendly competitive procurement considers the system costs and benefits of RE in the award decision by minimizing both generation and system integration costs. System-friendly RE competitive procurement can support a higher uptake of RE in three ways. First, system-friendly competitive procurement can improve the match between power supply and demand by procuring more dispatchable RE to meet the demand, even during peak times. Second, system-friendly competitive procurement can minimize transmission costs by procuring electricity from installations that entail fewer grid integration challenges. Third, system-friendly RE procurement can minimize intermittency in RE by procuring complimentary firm power that reduces the need for system balancing.

This paper draws from three sources: desktop research, primary information gathered during a scoping trip, and a July 2019 power sector stakeholder workshop in India that included SECI, CERC, GERC and project developers. It identifies **four global trends in innovative system-friendly RE procurement,** namely, time-based incentives and penalties (Global Trend 1), aggregators or virtual hybrids (Global Trend 2), procurement of (physical) hybrid solutions (Global Trend 3) and locational signals (Global Trend 4).

Time-based incentives and penalties incentivize RE generation to more closely match the demand curve (e.g., through price adjustment factors, supply blocks). Chile implemented intraday and seasonal supply blocks to allow intermittent technologies to optimize their feed-in potential and guarantee continuous supply to distribution companies. Awarded bids, which are backed by new RE projects, will provide continuous power within the defined block at an average cost of 3.25 cents/kWh (2.24 INR/kWh) – the lowest price ever recorded in the country.

Aggregators/virtual hybrids refer to RE installations at different grid connection points that are bundled and dispatched via virtual control systems. Virtual hybrids aggregate electricity from several generators and can thus feed in exactly as much electricity as has been purchased. In Germany, the virtual power plant, Next Kraftwerke, bundles intermittent RE in a portfolio to provide flexibility services in the market. Since 2016, Next Kraftwerke has been providing aggregated power for primary, secondary and tertiary reserve, thereby reducing the provision of these products by thermal generation.

Competitive procurement of RE electricity from physical hybrid installations aims to tap complementary generation profiles to offset technology-specific intermittencies and reduce interconnection costs. Besides India, Thailand also implemented hybrid procurement for firm energy to ensure a continuous supply of electricity even during peak hours. The 2017 hybrid scheme round awarded 300 MW to RE technologies providing a firm power supply at 7.39 cents/kWh (5.13 INR/kWh), which would otherwise be provided by thermal power plants. The procurement of

physical hybrid installations requires a careful parametrization of design elements due to the cost and plant configuration differences with a single technology installation.

Locational signals aim to steer the location of projects to specific areas/grid connection points that avoid the concentration of projects in resource-rich but costly-to-connect areas. They include bonuses/penalties for bids located in areas with available/insufficient grid capacities, RE development zones with simpler permitting processes, capacity quotas at regional or grid connection point level or site-specific competitive procurement. Kazakhstan implemented capacity quotas to limit transmission costs. The competitive procurement contracted 857.93 MW of RE projects that will be located at nodes with sufficient grid capacities to help minimize the need for grid expansion.

India has experience with innovative procurement approaches for RE system integration. The most prominent has been the competitive procurement of hybrid wind-solar plants by SECI. The table below gives a non-exhaustive overview of how the country considers system-friendliness in its RE procurement, which apply to one or more of the global trends analyzed.

Examples of System-Friendly RE Procurement in India

Example	Description	Link to global trend
SECI competitive procurement for hybrids	Roughly 6 GW of physical hybrids have been tendered (both announced and completed rounds) in the past two years. Most of this capacity is represented by wind-solar hybrids (2.59 GW), followed by floating solar (1.72 GW) and solar PV-battery storage (1.46 GW/3.96 GWh).	Physical hybrids (Global Trend 3)
SECI competitive procurement for hybrids with assured peak power supply	SECI will sign power purchase agreements (PPAs) with successful bidders for a period of 25 years. Successful projects receive time-based tariffs: a peak and an off-peak tariff. For energy generated during peak hours (6-9am and 6pm-12am), producers will be remunerated with a peak tariff determined through competitive procurement. The off-peak tariff was administratively-set at 2.70 INR/kWh (3.89 cents/kWh).	Time-based incentives and physical hybrids (Global Trends 1 and 3)
SECI as demand aggregators	SECI sometimes acts as an intermediary off-taker, signing PPAs with state DISCOMs or institutional off-takers. This service is provided against a fee or trading margin of roughly 0.04 - 0.07 INR/kWh (0.06 cents - 0.10 cents/kWh) charged by SECI to DISCOMs on top of the power sale tariff.	Aggregator (virtual hybrids) (Global Trend 2)
Bundling solar PV with thermal power	Since 2018, coal-fired power plants with regulated tariffs are allowed to blend thermal power with RE sources. DISCOMs, in turn, will benefit from the firm power provided by the blended electricity and half of the net gains resulting from lower RE electricity price procured by power producers.	Aggregator (virtual hybrids) (Global Trend 2)
Banking power arrangements	The practice of energy banking entails two DISCOMs entering into an energy exchange arrangement to match seasonal variation in surplus and deficit situations. Energy banking represents roughly 60% of the bilateral power trade market.	Aggregator (virtual hybrid) (Global Trend 2)

Examples of System-Friendly RE Procurement in India		
Example	**Description**	**Link to global trend**
State-level competitive procurement	State-level competitive procurement provides locational signals by limiting project locations to their specific license area. These regional rounds limit project sites to state boundaries and can thus more closely account for grid connection restrictions at the state level.	Locational signals (Global Trend 4)
Capacity quotas: Substation-specific competitive procurement	In substation-specific competitive procurement in states like Maharashtra and Andhra Pradesh, bids can only be awarded within the capacity of the substation.	Locational signals (Global Trend 4)
SECI site-specific competitive procurement	Site-specific competitive procurement has been implemented in SECI's solar parks, where the grid connection and permits are provided with the site.	Locational signals (Global Trend 4)

RE hybrid procurement supports system integration in India in several ways. First, physical hybrids contribute to lower RE grid integration/transmission costs. This is because of a higher capacity utilization factor (CUF), which results in an increased capacity utilization of the power evacuation infrastructure and lower grid connection and maintenance costs, compared to single technology RE installations. However, RE producers in India have not been compensated for this system benefit so far, given that grid connection costs are currently not charged to them. Second, hybrid plants with storage can contribute to a better matching of generation with the demand curve. In case such installations are incentivized by time-based tariffs or supply blocks, they can more closely align generation with peak demand. Finally, hybrids can contribute to balancing out intermittency given that the co-location of different technologies in one installation can result in more balanced generation curves throughout the day and year.

However, there are challenges in the implementation of RE hybrid procurement in India. First, setting uniform and ambitious CUF and ceiling prices across states can either restrict the number of participating bidders or risk the non-completion of awarded projects. Moreover, it remains to be seen whether successful bidders offering a high CUF of up to 40% will be able to meet the requirement year-round despite the seasonal variability of RE and how many more bidders can secure sites in locations with sufficient resource potential. The **draft guidelines on wind-solar hybrid competitive procurement** issued by MNRE in October 2019 give RE producers the option to revise the CUF during the first three years of operation. This option gives them the flexibility to consider plant performance and gather better site measurements, which supports compliance with the CUF. However, the minimum 30% CUF still does not consider different regional resource potential and seasonal variability. Second, the fixed costs of long-term contracts with thermal generation present in some states, coupled with overcapacity, may affect DISCOMs' willingness to invest in RE generation, including hybrid projects. Hence, DISCOMs may be inclined to procure least-cost RE rather than hybrid installations despite their potential savings in grid connection compared to single technology solar or wind projects.

This white paper concludes with the following **recommendations** for procuring institutions in designing a more system-friendly RE procurement:

- **Continue to develop procurement guidelines that support RE delivered at least cost instead of RE generated at least cost** to induce overall system cost savings and promote system-friendly RE projects. This can be achieved by revising the regulatory provisions associated with the exemption of RE grid integration and transmission costs as well as a further developing of model procurement documents that enable the implementation of system friendly RE projects. The draft guidelines on wind-solar hybrid competitive procurement issued by MNRE in October 2019 represent an important step in the support of state and central/-level procuring entities. This could be further developed by offering guide documents on how to define specific design elements such as ceiling prices and bidding parameters to procure RE power that is less intermittent or guaranteed during specific hours of the day. Potential agencies to undertake regulatory revisions can include CERC, SERCs and FoR. A model procurement document can be developed by SECI, MNRE and FoR.

- **Design tender documents to allow for RE procurement with time-based incentives and supply blocks to promote dispatchable RE**. This would allow time responsive and dispatchable RE to align to a liquid wholesale market generating time-specific price incentives. The tender documents can be developed by RE procuring agencies such as SECI, DISCOMs and state procurement agencies, and can include bulk consumers of power such as Indian Railways and DMRC.

- **Design procurement guidelines to promote strong locational signals for RE** to optimize RE project locations and development and reflect an optimal trade-off between system benefits, such as reduced grid extensions/reinforcements and RE generation costs. Locational signals can be included by RE procuring agencies such as SECI, DISCOMs and state procurement agencies and informed by transmission assessments by POSOCO and state transmission system operators.

- **Recognize the value of firm RE power supply**. The intermittency of RE power and consequent need for balancing should be addressed through system-friendly RE procurement designs such as procurement from physical or virtual hybrids. To incentivize the use of virtual, dispatchable hybrids, stricter norms for RE forecasting deviation should be applied for RE plants or a balancing market created for additional revenue streams for RE plants. Similarly, SECI, DISCOMs and state procurement agencies can facilitate a less intermittent RE generation by compensating storage and by separate procurements for more stable physical RE hybrids.

- **Tailor RE procurement design to regional conditions** to reduce the risk of geographical concentration at project sites and states with the best resources. For physical RE procurement, SECI, DISCOMs and state procurement agencies should consider different ceiling prices across states or regions with different RE resources and take seasonal RE generation patterns into account when setting the capacity utilization factor.

- **Engage bidders early to minimize RE procurement under subscription**. Prior consultation with bidders, lenders and industry expert can help to alert procuring institutions on potential pitfalls and to create a bankable process. Publishing the draft and final versions of tender documentation increases transparency in the process. All procuring agencies (SECI, DISCOMs and state procurement) should facilitate the engagement process, and bidders, investors and industry associations should actively and vocally participate.

INTRODUCTION

Renewable energy prices have fallen dramatically worldwide. A major contributor to these price declines has been the competitive procurement of renewable energy (RE) sources. In India, record-low prices in RE competitive procurement rounds have been driven by continuous technological improvements, including higher solar PV module efficiencies, a commitment to large-scale RE deployment, and increasing experience and competition among project developers and manufacturers. However, as the proportion of RE grows in power systems, system integration challenges and associated costs emerge gradually. According to a study by the Central Electricity Authority (CEA), in states like Tamil Nadu and Gujarat, RE integration costs were almost 1.5 INR/kWh[1] (2.16 cents/kWh) in 2017,[2] or more than half of the recent RE bid prices.

India needs to auction 40 GW of solar and wind capacity every year until 2028[3] to meet its RE target of 40% of total installed capacity by 2030.[4] Given the significant RE capacities yet to be procured and commissioned, competitive procurement can be an opportunity to purchase a power mix with system-friendly attributes. System-friendly competitive procurement incentivizes the deployment of variable RE by considering the system costs and benefits of RE in the award decision. By incentivizing generation that accounts for the system cost and benefits of renewables, system-friendly RE competitive procurement can enable the electricity distribution companies in India (DISCOMs) to increase the uptake of RE generation and reduce their power purchase cost[5] by taking advantage of falling RE prices.

This paper first discusses the relevance of system-friendly RE competitive procurement in India. It then analyses the experience with RE hybrid procurement and other system system-friendly approaches implemented in India. Next, four international trends on innovative RE procurement (time-based incentives and penalties, aggregators (virtual hybrids), competitive procurement of physical hybrid solutions, and locational signals) are presented, as well as initial considerations for applying them in India. The paper concludes with recommendations and an outlook on future work for energy policy authorities.

Table 1. List of Key Terms Used

Term	Definition
Competitive procurement	A competitive process for procuring electricity generated by RE.[6] It is designed to allocate a supply contract or incentive based solely on the bids submitted by participating bidders according to transparent award rules.[7] The bid evaluation criteria can be based solely on price or include such additional award criteria as system integration, the creation of a local industry, the environmental impacts of a project, or its local/social acceptability. The terms "tender" and "auction" are also used to designate this type of procurement process. "Competitive procurement" is used in this paper as it is the preferred term in India's energy industry.

[1] Prices reported in parenthesis throughout the paper are the result of a currency conversion of the price cited in the sources. To convert Indian rupees to US dollars, the price was multiplied by 0.0144 (1 INR = 0.0144 USD). To convert US dollars to Indian rupees, the price is multiplied by 69.3510 (1 USD = 69.3510) (Reuters, 2019a).
[2] For Gujarat, these estimated costs include total balancing charges for ramping up coal and gas power plants (0.24 INR/kWh or 0.35 cents/kWh), deviation settlement payments (0.12 INR/kWh or 0.17 cents/kWh), tariff impacts for distribution companies as a result of backing down coal generation (0.5 INR/kWh or 0.72 cents/kWh), stand-by charges (0.33 INR/kWh or 0.48 cents/kWh) and additional transmission charges (0.26 INR/kWh or 0.37 cents/kWh) (CEA, 2017).
[3] (Economic Times, 2018)
[4] (Reuters, 2019b)
[5] In India, the power purchase cost is typically 70 to 80% of the distribution company's total annual expenditure.
[6] (IRENA, 2015)
[7] (AURES, 2015)

Table 1. List of Key Terms Used	
Term	**Definition**
System integration of RE	This encompasses all the technical, institutional, policy and market design changes needed to enable the secure and cost-effective uptake of large amounts of RE in the energy system.[8] Examples include grid expansion and upgrades, system operating procedures and market practices, as well as power system planning.[9]
System integration cost	The cost imposed on the power system to integrate a resource. The concept highlights that generation costs do not reflect the full cost (and value) of a resource.[10] The calculation of system integration costs is complex, and results depend on the costs included, the methodology applied, and whose perspective is considered. Examples include grid expansion and upgrade cost, balancing costs to offset the differences between forecasts and actual production, provision of firm reserve capacity, and cost of cycling and ramping of conventional plants.
System-friendly attributes	The specific characteristics that allow for an easier system integration of RE and thus lower barriers for their increasing uptake.
Variable renewable energy	Electricity generation technologies whose primary energy source varies overtime and cannot easily be stored. Variable generation sources include solar, wind, ocean, and some hydro generation technologies.[11]

This paper draws from desktop research and primary information gathered during a scoping trip and a workshop with power sector stakeholders in India in July 2019 lists the organizations consulted. Their comments and suggestions were of great value for this paper, while the positions presented in the paper do not necessarily constitute their opinions.

Table 2. Overview of Stakeholders Consulted, July 2019	
Name	**Sector**
Adani Green Energy Ltd.	Developer
ReNew Power Ltd.	Developer
Ministry of New and Renewable Energy (MNRE)	Government
Solar Energy Corporation of India (SECI)	Government-owned enterprise
Railway Energy Management Corporation Limited	Government-owned enterprise
Central Electricity Regulatory Commission (CERC)	Power sector regulator
Gujarat Electricity Regulatory Commission	Power sector regulator
MERCOM India	Analyst
Central Electricity Authority (CEA)	Government agency
Power System Operation Corporation Limited (POSOCO)	Government-owned enterprise
Stakeholders' workshop hosted by SECI	POSOCO, CERC, SECI, Madhya Pradesh State Government, Uttar Pradesh State Government, TPDDL, BSES and CBIP.

[8](IEA, 2018)
[9] (USAID, NREL, n.d.)
[10](Palchak, et al., 2017)
[11] Taken from the Greening the Grid website. Available at: https://greeningthegrid.org/about/glossary/glossary#V

1. RELEVANCE OF SYSTEM-FRIENDLY RE PROCUREMENT

System-friendly RE procurement represents an opportunity to increase the uptake of RE in India. Cost decreases have allowed India to contract RE generation at prices as low as 2.50 INR/kWh (3.60 cents/kWh) for solar in 2019,[12] 2.51 INR/kWh (3.61 cents/kWh) for wind in 2018,[13] and 2.69 INR/kWh (3.87 cents/kWh) for wind-solar hybrids in 2019.[14] Low tariffs have increased the business case for RE against thermal power, while the National Thermal Power Corporation (NTPC) reported an average cost of generation of 3.42 INR/kWh (4.93 cents/kWh) in 2018, with a large majority of its operational capacity based on coal- and gas-based power plants.[15]

System costs, however, will become more important as more RE generation is added to the grid. Adding RE to the grid can induce additional costs related to grid connection, extension and reinforcement, curtailment, redispatch, balancing, and grid losses. As mentioned above, a CEA study estimates that grid integration costs were almost 1.5 INR/kWh (2.16cents/kWh) in 2017 in states like Tamil Nadu and Gujarat, or more than half of recent RE bid prices. These costs are currently not reflected in RE power tariffs.

1.1THE OPPORTUNITY FOR SYSTEM-FRIENDLY RE PROCUREMENT

By moving away from minimizing only generation costs to minimizing both generation and system integration costs, system-friendly competitive procurement represents an opportunity to support a higher uptake of RE in three ways:

First, system-friendly competitive procurement can **improve the match between power supply and demand**. A challenge faced by DISCOMs is to respond to changes in demand patterns and the trend toward higher evening peaks. Over the past five years, the evening peak demand in India has continuously risen, from 128.3 GW in 2013 to 174.7 GW in 2018.[16] Ramping requirements also increase as peak demand increases, particularly with higher shares of solar that does not have storage. For example, by 2030, the ramping need (capacity increase needed per hour)in Karnataka is expected to rise to 30% of peak demand[17] from its current levels of 14%.[18]

Peak demand varies across states. Maharashtra's load, for example, peaks during the day due to its prominent industrial load. In contrast, Delhi's mostly domestic and commercial load peaks in the late afternoon/night in the summer (due to high cooling load demand) and in the morning hours during winter.[19] Procuring more dispatchable, low-cost RE to meet demand, even during peak times, can help address this challenge. Options include incentives via higher tariffs or supply blocks following load patterns or the procurement of electricity from hybrids including dispatchable RE installations or storage.[20]

Second, system-friendly competitive procurement can **mitigate transmission costs**. A challenge in India's power system is grid constraints at the transmission level, which lead to congestion and

[12](Prateek, 2019a)
[13](Prateek, 2018a)
[14](Prateek, 2018b)
[15](Prateek, 2018c)
[16](Parray, Tongia, 2019)
[17] Assuming India meets the government's current renewable energy targets. The estimate is based on demand and supply scenarios developed by The Energy Resources Institute India (TERI) and the Energy Transitions Commission India (ETC India).
[18](Udetanshu, Pierport, Nelson, 2019)
[19](POSOCO, 2016)
[20] The use of storage before the meter and after the meter is still in a nascent stage in India. However, stored RE generation can be a potential source for both reducing excess energy on the system and supplying stored power when it is required (e.g., during peak demand periods).

curtailment. The CEA estimates INR 2.69 trillion ($39 billion) of investment are needed at the transmission level by 2022 to build 110,000 circuit kilometers (of transmission lines) and about 383,000 MVA of transformation capacity in the substations at the 220kV-level and above.[21] RE transmission costs can be reduced by procuring electricity from installations that pose fewer grid integration challenges.

For example, by requiring minimum capacity utilization factors (CUF) from producers, the existing transmission infrastructure can be better utilized in line with an optimization of the ratio of MWh per MW of transmission capacity. In this case, projects need to deliver a minimum CUF or face a penalty. The prescribed minimum CUF can differ between states and should be tailored to complementary generation patterns between solar and wind. Pricing in grid connection costs in bids is also an option to incentivize projects with lower connection costs.

Last, system-friendly competitive procurement can **reduce intermittency**. Another challenge faced by India's power sector is the management of intermittent RE generation, which requires the balancing of real-time shortages and surpluses with generation and supply-side resources. By procuring more firm power, e.g., from virtual or physical hybrids with higher CUFs, the need for balancing in the system can be reduced.

1.2 RE SYSTEM INTEGRATION IN INDIA

Key issues being discussed around the integration of RE generation in India include the introduction of grid connection charges for RE projects, a potential phase-out of the "must-run" status of RE, the introduction of responsibility for forecast deviations for RE in all states, and the wholesale electricity market reforms proposed by the Central Electricity Regulatory Commission (CERC).These developments, when they materialize, would place more system responsibilities on RE producers and influence the policy framework for system-friendly procurement.

A first development is the **expiration of the waiver of grid connection charges for RE projects in 2019,**[22] and the waiver of transmission charges for the use of the inter-state transmission system (ISTS) in 2022.[23] ISTS waivers aim to incentivize the development of projects in areas with large amounts of RE resources. Solar and wind projects awarded via competitive procurement that enter operations by March 2022 will still be exempt from paying transmission charges. With the expiration of these waivers, grid connection and use costs will be priced into bids and the tariffs for RE may increase. As RE producers internalize these costs, there will be an incentive to reduce RE deployment in areas with grid congestion.

A second development is the **potential phase-out of the "must-run" status of RE.** Currently, RE in India enjoys a must-run status in the merit order dispatch. This provides high revenue certainty for RE developers and helps to de-risk their projects. On the other hand, it reduces the incentive to invest in accurate forecasting and, where possible, optimize generation to more closely follow the demand curve and reflect grid constraints. In 2017, the states of Tamil Nadu and Madhya Pradesh proposed to remove the must-run status, but later opted to maintain it. However, it is possible this status will be removed in the future to allow for the curtailment of renewables in certain dispatch

[21](Bajaj, 2019)
[22](USAID, MNRE, 2017)
[23](CERC, 2019)

situations, as modern wind and solar power plants can be controlled to provide downward economic dispatch.[24]

A third development is the **introduction of responsibility for forecast deviations for RE generation**. CERC released forecasting and deviation limits for inter-state solar and wind energy projects in 2015, followed by a similar regulation by the Forum of Regulators (FoR) for intra-state projects in the same year.[25] As of August 2019, 15 states had passed their final forecasting and scheduling regulation. In most of these states, there are no penalty charges for forecast deviations above or below 15% except for Gujarat, Haryana, Uttar Pradesh and Tamil Nadu, where the range is less than 10%. So far, five states –Chhattisgarh, Madhya Pradesh, Andhra Pradesh, Karnataka, and Rajasthan – have begun to impose penalties on generators.[26] For inter-state solar and wind projects, the regulation defines penalties for forecast errors that exceed 15% of available capacity.[27] Some RE producers fear the increasing costs of improved forecasts, and point to the unfair competition that would arise with thermal power plants, which can better control their generation.

A fourth development is **CERC's proposed wholesale electricity market reform.**[28] Most DISCOMs' self-schedule[29] the generators with which they have bilateral contracts. Self-scheduling can lead to extensive curtailment of RE and higher marginal power costs for DISCOMs and the system. CERC has thus proposed a centralized day-ahead scheduling and real-time dispatch. A liquid power market could generate time and locational price signals not only for RE generation, but for the entire power system.

To conclude, system integration costs will become more important as more RE generation is added to the grid. By moving toward minimizing both generation and system integration costs, system-friendly RE competitive procurement can support the higher uptake of RE. Also, the policy framework and relevance of system-friendly procurement will be influenced by the introduction of more system responsibilities for RE such as grid connection charges for RE projects, a potential phase-out of the "must-run" status of RE, responsibility for forecast deviations, and the proposed wholesale electricity market reforms.

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[24](Palchak, et al., 2017)
[25](Prayas (Energy Group), 2018)
[26](JMK Research, 2019)
[27](USAID, Ministry of Power of India, 2017)
[28](Patel, 2019)
[29] Self-scheduling refers to the practice followed by DISCOMs to requisition power from the generating stations with which they have contract (CERC, 2018).

2. ENABLING SYSTEM-FRIENDLY RE PROCUREMENT

2.1 STATUS OF SYSTEM-FRIENDLY PROCUREMENT IN INDIA

DISCOMs have RE targets dictated by renewable purchase obligations[30] (RPOs) and state-level RE policies. DISCOMs can procure RE capacity either directly or via the Solar Energy Corporation of India (SECI) and the National Thermal Power Corporation (NTPC). Competitive procurement of RE will continue to be an important vehicle for purchasing the capacities India needs to meet its ambitious RE target of 175 GW by 2022. The mechanism covers single technologies (solar PV, floating solar and wind) and since 2018 RE hybrid solutions (e.g., wind-solar, solar-storage). Between 2012 and June 2019, 81.5 GW of RE capacity have been tendered at both the central and state levels, including: 63.7 GW of solar, 14.5 GW of wind, 3.2 GW of hybrid, and roughly 50 MW of storage capacities.[31]

India offers several examples of promoting system integration in competitive procurement, including RE hybrids gives a non-exhaustive overview of examples of how the country considers "system-friendliness" in its RE procurement, which are linked to one or more of the global trends analyzed in Section 3.

Table 3. Examples of System-Friendly RE Procurement in India

Example	Description	Link to global trend
SECI competitive procurement for hybrids	Table A in the Annex provides an overview of selected competitive procurement rounds for (physical) hybrid solutions conducted or announced during 2018-19. Although the table is not exhaustive, selected rounds show that roughly 6 GW of physical hybrids have been tendered (both announced and completed rounds) in the past two years. Most of this capacity is represented by wind-solar hybrids (2.59 GW), followed by floating solar (1.72 GW) and solar PV-battery storage (1.46 GW/3.96 GWh). Comparatively smaller volumes have been defined for solar-wind-optional storage (160 MW), and floating solar and battery storage hybrids (20 MW/60 MWh).	Physical hybrids (Global Trend 3)
SECI competitive procurement for hybrids with assured peak power supply[32]	SECI will sign power purchase agreements (PPAs) with successful bidders for a period of 25 years. Successful projects receive time-based tariffs: a peak and an off-peak tariff. Energy generated during off-peak hours (9:01am – 6 pm and 12:01am – 5:59am) will be remunerated with a flat administratively-set off-peak tariff payment of 2.70 INR/kWh. For energy generated during peak hours (6am – 9am and 6pm to 12am), producers will be remunerated with a peak tariff determined through competitive procurement, that is projects only bid on the peak tariff.	Time-based incentives and physical hybrids (Global Trends 1 and 3)
SECI as demand aggregators	SECI sometimes acts as an intermediary off-taker, signing PPAs with state DISCOMs or institutional off-takers. This service is provided against a fee or trading margin of roughly 0.04 - 0.07 INR/kWh[33] (0.06 cents - 0.10cents/kWh) charged by SECI to DISCOMs on top of the power sale tariff.	Aggregator (virtual hybrids) (Global Trend 2)

[30]RPO targets are the most important policy driving RE deployment in India. Most states currently fail to achieve their set RPO targets. In 2018, 27 states achieved less than 60% of their RPO target. States like Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Mizoram, Nagaland, Rajasthan, Tamil Nadu, Tripura and Uttarakhand are the only states that have achieved at least 60% of RPO compliance (Prateek, 2019b).
[31](BNEF, 2019)
[32](SECI, 2019)
[33] CERC has capped short term trading margins at 0.07 INR/kWh (if the sale tariff is greater than 3 INR/kWh) and 0.04 INR/kWh (if the sale tariff equals or is less than 3 INR/kWh) (Thomson Reuters - Practical Law, 2019)

Table 3. Examples of System-Friendly RE Procurement in India		
Example	**Description**	**Link to global trend**
Bundling solar PV with thermal power	The policy for bundling thermal power with RE sources was announced by the Indian government in 2018 to give coal-fired power plants with regulated tariffs the flexibility to generate and blend electricity from solar and wind. DISCOMs, in turn, will benefit from the firm power provided by the blended electricity and half of the net gains resulting from lower RE electricity price procured by power producers[34] (for example, NTPC competitive procurement for 2 GW of RE blended and then sold to DISCOMS for the price of coal PPAs).[35]	Aggregator (virtual hybrids) (Global Trend 2)
Banking power arrangements[36]	The practice of energy banking entails two DISCOMs entering into an energy exchange arrangement to match seasonal variation in surplus and deficit situations. Energy banking represents roughly 60% of the bilateral power trade market.[37]	Aggregator (virtual hybrid) (Global Trend 2)
State-level competitive procurement	State-level competitive procurement provides locational signals by limiting project locations to their specific license area. Compared to site-agnostic, central-level rounds, these regional rounds limit project sites to state boundaries and can thus more closely account for grid connection restrictions at the state level.	Locational signals (Global Trend 4)
Capacity quotas: Substation-specific competitive procurement	In substation-specific competitive procurement in states like Maharashtra and Andhra Pradesh, bids can only be awarded within the capacity of the substation.	Locational signals (Global Trend 4)
SECI site-specific competitive procurement	Site-specific competitive procurement has been implemented in SECI's solar parks, where the grid connection and permits are provided with the site.	Locational signals (Global Trend 4)

Compared to the other examples, the procurement of physical hybrids has been developed more through the launch of national and state policies, and the implementation of several procurement rounds since 2018. The following section presents an analysis of the experience with the procurement of physical hybrids in India.

2.2 STATUS OF HYBRID PROCUREMENT IN INDIA

Two central-level competitive procurement procedures for large-scale hybrid installations have been held by SECI, as of September 2019.[38] In the first round, held in 2018, SECI awarded 840 MW split between two projects at 2.69 INR/kWh (3.87 cents/kWh).[39] In the second round, held in 2019, SECI awarded a 600MW project at 2.69 INR/kWh (3.87 cents/kWh) and a 120MW project at 2.70 INR/kWh (3.89 cents/kWh).[40]

Physical hybrids in India currently aim at an efficient utilization of land (i.e., kWh/m^2) and transmission capacity (i.e., MWh/MW), as well as a reduction in the intermittency of RE generation

[34](Ministry of Power, 2018)
[35](India Times, 2018)
[36]For example, North Delhi power supplier Tata Power Delhi (TPDDL) uses power banking extensively and has been reported to have entered into such power banking arrangements with several states, including as Jammu & Kashmir, Madhya Pradesh, Meghalaya and Odisha throughout 2014 and 2015 (India Times, 2015a).
[37](PTC India, n.d.)
[38] According to the e-tenders listed in the SECI website, http://seci.co.in/tenders.php, consulted on September 26, 2019
[39](Prateek, 2018b)
[40](India Times, 2019)

to increase grid stability. System-friendly attributes can be incentivized as part of the design of competitive procurements for hybrids. Two main options are possible. The first is through **multi-criteria auctions**, against which projects are evaluated, or **time-based compensation/penalties** (see Global Trend 1 in Section 3) for providing generation that more closely matches the load profile. The second is to define **eligibility criteria** such as a minimum capacity utilization factor (CUF). In case of a generation shortfall from the declared minimum generation requirement, penalties apply.

The recently held SECI competitive procurement for solar-wind hybrid projects focused on eligibility criteria, coupled with penalties.[41] A guaranteed generation requirement was defined in the form of a CUF of at least 30-40%. Penalties applied in case actual generation fell below 90% of the declared CUF, while excess generation beyond 120% of CUF could be sold at the full PPA tariff.

2.3 RE HYBRID PROCUREMENT SUPPORTING SYSTEM INTEGRATION IN INDIA

How do hybrids contribute to lower RE grid integration/transmission cost?

RE projects with a higher CUF, such as physical hybrids, have lower grid connection costs than single solar PV and wind projects. Hybrids make fuller use of the grid and in general entail savings in connection, operations and maintenance costs.[42] By physically co-locating wind and solar projects, the capacity utilization of power evacuation increases compared to single solar PV and wind projects. Grid connection costs are, however, not yet charged to the RE producer, therefore the producer is not yet compensated for the system advantage. Instead, grid connection costs are socialized, i.e., they are allocated across all parties connected to the grid. DISCOMs, aiming to achieve their RE targets at lowest costs, therefore often decide to just procure single-technology RE instead. If RE producers need to pay for grid connection costs from 2022 onwards, the system advantage of hybrids would be priced in and compensated, making hybrid projects more competitive.

How do hybrids contribute to generation further matching the demand curve?

Variable RE generation is not always problematic if it matches the demand curve. For this purpose, time-based tariffs or supply blocks could provide a better demand-generation match but need to be adapted to local demand profiles. Hybrid RE plants with storage can more closely align generation with peak demand through the payment of an "peak tariff," as exemplified by the SECI tender for the supply of electricity for a minimum of six hours per day during periods of peak demand.[43]

How do hybrids contribute to balancing out intermittency?

Combining different technologies such as wind and solar in one installation can result in more balanced generation curves throughout the day and year and lower peak-to-average power ratios for the same hour throughout the year. For example, since solar generation usually peaks around noon, whereas wind typically picks up in the afternoon, a hybrid of the two technologies can smoothen out the generation output throughout the day. Figure 1 illustrates the complementarity of wind and solar generation patterns at a wind-only, solar-only and a hybrid power plant at a location in northwest India.

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[41](SECI, 2018)
[42](Utility Dive, 2018)
[43](SECI, 2019)

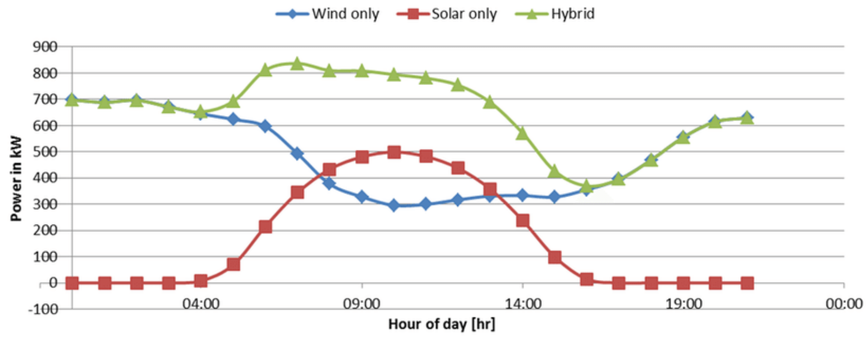

Figure 1- Average hourly power generation profile of a 1.5 MW wind, a 750 kWp solar and true hybrid for a location in North Western India (Agrawal, Khemka, Manoharan, Jain, & Mukhopadhyay , 2016)

Hybrid plants incorporating storage (e.g., pumped hydro or batteries) can provide balancing energy to the grid. However, RE producers currently have little incentive to use batteries or hydro-pumped storage for balancing given the exemption from penalties for forecast deviations up to 15% of available capacity, and the higher technology costs compared to other RE technologies. Enabling the participation of storage in an extra balancing market would create an incentive for this technology.

2.4 CHALLENGES OF HYBRID PROCUREMENT IN INDIA

The stakeholders consulted for this study raised issues regarding the design of the CUF and ceiling prices, how the fixed costs of thermal generation lower the DISCOMs' appetite for hybrids, and risks stemming from delays in grid connection and frequent curtailment.

Setting a *uniform and ambitious CUF and ceiling prices across states*, which would be only achievable in regions with higher RE resource potential, can either restrict the number of participating bidders or risk the non-completion of awarded projects due to the winner's curse.[44] Several developers stated that a ceiling price for hybrids of 2.70 INR/kWh (3.89 cents/kWh) was too low for their region, implying that only projects in a very few regions could be successful.[45]

Moreover, successful bidders offered a CUF of 40% even after SECI lowered the requirement to 30%. This, however, raises the questions of whether these bidders will be able to meet the requirement year-round despite the seasonal variability of RE, and how many more bidders can secure sites in locations with enough resource potential. Some stakeholders claimed that RE producers may choose to significantly oversize their projects to ensure a high CUF (during, e.g., seasons of low wind generation). While project over sizing has been common for solar PV projects, it is unclear whether significant over sizing would be financially viable for wind-solar hybrids. Because of the effect of the CUF on the technology choices made by RE producers given the resource potential of available sites, the appropriate value needs to be set carefully.

In some states, the *fixed costs of long-term contracts with thermal generators*, coupled with overcapacity, affect DISCOMs' appetite for RE uptake, including hybrid projects. Several DISCOMs have long-term take-or-pay PPAs with thermal power plants. Fixed costs in the form of capacity charges also accrue even if no power is being taken by DISCOMs, which often can be the case due to the must-run status of RE. If thermal power is un-requisitioned despite being available (in other words, is backed down), the DISCOM has to bear the fixed charges, which can be roughly 1.39-1.66 INR/kWh[46] (2.00

[44] The winner's curse occurs when a winning bidder underestimates the true costs and is not able to build the project.
[45] 70% of India's RE potential lies in seven of the country's 28 states.
[46](Dash, 2019)

– 2.39 cents/kWh), depending on the thermal power contract type. Despite the potential savings in grid connection costs from hybrids compared to single solar PV and wind projects, DISCOMs would rather procure least-cost RE. However, with many thermal power plants approaching the end of their lives, this burden from fixed costs will increasingly become less of an issue. Approximately 22.7 GW of coal-based capacity is to be retired between 2017 and 2022. Another 25.5 GW is being considered for retirement during 2022-2027, which will be completing 25 years of operation by March 2027.[47]

Further challenges mentioned for hybrid and single-technology competitive procurement include *delays in substation and related grid-connections, frequent curtailment in several states* (Andhra Pradesh, Karnataka) with high RE shares, *land issues* increasing bid prices in some states (e.g., Rajasthan*), limited land available for state-level competitive procurement* (e.g., Gujarat), and the *lower credit rating* of many DISCOMs. Delays in gaining access to the grid, for example, begs the question of whether the 18-month project commissioning deadline from the effective date of the PPA for hybrids will be enough. Prices in state-level competitive procurement rounds have been higher than at the central level. The higher risk perception of DISCOMs compared to SECI or NTPC, as off-takers and procuring entities backed by a government payment security, partly explains the higher tariffs observed at the state level. In 2018, the weighted average tariff across RE technologies for central-level competitive procurement was 2.61 INR/kWh (3.76 cents/kWh) compared to 2.92 INR/kWh (4.20 cents/kWh) in state-level rounds.[48]

On October 11, 2019, MNRE issued Draft Guidelines for Tariff-Based Competitive Bidding for Wind-solar Hybrids, open to comments until October 31, 2019. The final guidelines will be binding for procuring entities.[49]

Table 4. MNRE Draft Guidelines on Wind-solar Hybrid Competitive Procurement[50]

Design elements	Preliminary assessment
Timeline for bid process	A time table provides states with guidance on the envisioned lead time for every stage of the competitive bidding process, namely: the date of issue of tender documents; the bid clarification stage; the bid submission stage (after 30-45 days); the bid evaluation and award stage (after 75 days); and the PPA signing stage (after 105 days). The definition of a bid clarification stage also helps the market prepare for bid submission and reduces the risk of bids being disqualified on formal grounds. The lead time of a minimum 30 days between announcement of the bid process and bid submission does not leave enough time in case bidders need longer to prepare or revise tender documents.
CUF	The option to revise the CUF at the time of the PPA signing during the first three years of operation gives bidders the flexibility to consider plant performance and gather better site measurements, which supports compliance with the CUF. However, the minimum 30% CUF still does not consider different regional resource potential and seasonal variability.
Ceiling tariff/price	The guidelines allow procuring entities to specify their own ceiling tariff/price. This gives them the flexibility to account for regional resource potential and lowers the risk of under subscription in cases where a uniform ceiling tariff proves too ambitious for most bidders.

[47](CEA, 2018)
[48](Suresh, 2018)
[49] Clause 3.3 of the Draft Guidelines specifies that, unless explicitly specified, the provisions of the guidelines shall be binding on the procurer. The process to be adopted in case of deviations from the proposed guidelines is specified in Clause 23 of the Draft Guidelines.
[50] Ministry of New & Renewable Energy (2019)

Table 4. MNRE Draft Guidelines on Wind-solar Hybrid Competitive Procurement[50]	
Design elements	**Preliminary assessment**
Bidding parameters	The guidelines give procuring entities the option to define parameters to procure RE with reduced intermittency or guaranteed supply for defined hours during the day. An additional, separate guideline for states with details on options and how to define these parameters, would further support the use of this option.
Evidence of project development for bid submission	The draft guidelines mitigate the risk of project delays by requiring evidence of land acquisition and a letter from the state or central grid operator confirming the technical feasibility of connecting the project to the identified substation.

3. GLOBAL TRENDS IN SYSTEM-FRIENDLY RE PROCUREMENT

As competitive procurement is the main vehicle used in India to procure RE capacity, innovative approaches to procurement bear the potential to encourage system integration and a higher and faster uptake of RE generation. This section analyzes selected global trends in innovative RE system-friendly procurement. Table 5 provides a summary of the trends.

Table 5. Overview of Global Trends in Innovative RE System-Friendly Procurement

Global trend	Description	Country experience
1. Time-based incentives and penalties	Design options that incentivize RE generation to more closely match the DISCOM demand curve (e.g., price adjustment factors, supply blocks).	**Chile** implemented intraday and seasonal supply blocks to allow intermittent technologies to optimize their feed-in potential and guarantee continuous supply to distribution companies.
2. Aggregator (virtual hybrids)	Aggregators/virtual hybrids refer to RE installations at different grid connection points which are bundled and dispatched via virtual control systems. Virtual hybrids aggregate electricity from several generators and can thus feed in exactly as much electricity as has been purchased.	The virtual power plant Next Kraftwerkein **Germany** bundles intermittent RE in a portfolio to provide flexibility services in the market. Hybrid solutions with storage create a quasi-dispatchable virtual power plant.
3. Procurement of (physical) hybrid solutions	Competitive procurement of RE electricity from installations combining technologies such as wind, solar, and potentially storage or dispatchable technologies such as bioenergy, with the aim of combining complementary generation profiles to offset technology-specific intermittencies and to reduce interconnection costs.	The **Brooklyn** Queens Demand Management Program (Con Edison, NY) showcases a fully integrated, technology-neutral hybrid scheme including RE generation, storage and demand services for the provision of capacity/reduction of load in the 4-8pm and 8pm-12am time window. **Thailand** implemented hybrid procurement for firm energy to ensure a continuous supply of electricity even during peak hours and to reduce intermittency of RE generation.
4. Locational signals	Locational signals aim to steer the location of projects to specific areas/grid connection points to avoid the concentration of projects in resource-rich but costly-to-connect areas. They include options such as bonus/penalties for bids located in areas with available/insufficient grid capacities, RE. development zones with simpler permitting processes, capacity quotas at regional or grid connection point level or site-specific competitive procurement.	**Kazakhstan** implemented capacity quotas to limit transmission costs from auctioned installations and ensure the system can absorb the additional generation capacity.

The list of trends is not exhaustive, yet it focuses on innovative approaches that directly target system integration and are more relevant to India. Global trends not covered in the white paper include premiums paid on top of power market revenues, and competitive procurement for ancillary services and grid capacity. These were not included for further analysis since they are less relevant to India due to, for example, the absence of a liquid wholesale and ancillary services markets or other global trends being further discussed.

- **Floor price for power market revenues:** The direct sale of RE electricity to the wholesale market could provide location- and time-specific price signals. Although the introduction of a centralized day-ahead power market is being considered in India, the Indian Energy Exchange (IEX) liquidity is still low, as only 4% of electricity transactions are traded through the power exchange[51]. Premium schemes[52] like Contract for Difference (CfD) in the UK, or a sliding premium in Germany, entail the trading of electricity at the power market since the premium paid to RE producers is calculated in reference to the market price. This guarantees a minimum revenue even if wholesale market prices drop below the expected prices. Due to low illiquidity of the IEX and the pending introduction of a centralized day-ahead market, premium schemes are currently less relevant to India.
- **Competitive procurement for ancillary services:** Ancillary services can be procured via competitive procurement by the grid operator. In Denmark, significant volumes of ancillary services are supplied by wind installations[53]. The competitive procurement design is open to all technologies capable of providing the required products. India is discussing a proposal by CERC for the introduction of ancillary services, however, this white paper focuses on system-friendliness through competitive procurement and not on the design of markets for ancillary services.
- **Competitive procurement for grid capacity:** Grid capacity rather than RE capacity or generation, could be tendered. Successful bidders are awarded the right to connect their project to a pre-established grid infrastructure in locations where RE integration is feasible. For example, obtaining grid connection for an offshore wind project in Germany requires a previous award in the respective procurement process. Since the focus of this trend is not directly on RE procurement, as practiced in India, this paper does not address it.

The following section presents an overview of selected global trends in innovative RE system-friendly procurement. For each trend, a description is provided, followed by international experiences, and initial considerations for application in India.

3.1 GLOBAL TREND 1: TIME-BASED INCENTIVES AND PENALTIES

DESCRIPTION

Time-based incentives include design options that incentivize RE generation that more closely matches the power demand curve. Measures can include price adjustment factors and supply blocks.

Time-of-day and time-of year price adjustment factors are designed to reward/punish electricity generation supplied at specific times of the day/year. The adjustment factor is typically applied to the price paid to the producers and not the bid price offered (although with the same results). By increasing or decreasing the price paid per kWh of generation, energy policy planners seek to reward supply that matches demand more closely.

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[51]The remaining share is tied up in PPAs between DISCOMs and power producers(CERC, 2018).
[52] Premium schemes can be symmetric or asymmetric. The CfD scheme used in the UK is an example of a symmetrical floating premium tariff that guarantees a fixed price for power producers. If the market price is below the auction (strike) price, a premium payment is made to the producer. If the market price is above the auction (strike) price, the producer has to pay back the difference. Most European countries (e.g., France, Germany, the Netherlands) operate asymmetrical floating premium schemes. Unlike in the UK's CfD scheme, a producer does not have to pay back the difference if it manages to sell electricity to the market at a higher price than the strike price.
[53](Energinet, 2017)(Klinge, 2018)

Supply blocks/commitments can require producers to guarantee continuous delivery during certain times or otherwise face penalties and require producers to purchase the missing electricity. Time-specific supply blocks allow RE producers to limit supply commitments to the times of day or year when they effectively generate electricity[54].

COUNTRY EXPERIENCE

Table 6: Intraday and Seasonal Supply Blocks in Chile	
Objective	Allow intermittent technologies to optimize their feed-in potential and guarantee continuous supply to distribution companies.
Design	Distribution companies provide demand projections for the next 10 years for energy, reactive power and peak demand. The regulator aggregates the projected supply requirements and conducts the competitive procurement. In the tender documentation, distribution companies provide bidders with information from the preceding five years on load factor, maximum energy demand and maximum energy demand in peak demand hours. Rather than requiring generators to follow an hourly profile matching the demand curve specified in the auctioned contracts, hourly supply blocks allow RE producers to concentrate their contractual commitments to the times of the day when they effectively generate electricity. Supply blocks transfer generation risks to the RE producer. Production deviations are settled at spot market prices. The supply blocks consist of three intra-day (12-8am + 11pm-12am; 8am-6pm; 6pm-11pm), and four three-month seasonal blocks. Each of the blocks has a base (annual energy requirement) and a variable component (10% of base component). The competitive procurement design allows for a transfer of offers from the intraday to the seasonal blocks if the offer was conditional on the three blocks being awarded and on defined blocks of the same size (i.e., amount of GWh offered). New solar and wind projects winning in the seasonal supply blocks are subject to greater risk exposure.

Supply Blocks Defined in Chile's 2017 RE Competitive Procurement[55]

Supply block type	Supply block duration	Base energy auctioned (GWh/year)	Variable energy auctioned (GWh/year)	Total energy auctioned (GWh/year)
Hourly	12-7:59am and 11-12:59pm	480	48	528
	8am-5:59pm	707.3	70.7	778
	6-10:59pm	358.2	35.8	394
Quarterly	1 Jan – 31 Mar	113.6	11.4	125
	1 Apr – 30 Jun	113.6	11.4	125
	1 Jul – 30 Sep	113.6	11.4	125
	1 Oct – 31 Dec	113.6	11.4	125
Total		1,999.9	200.1	**2,200**

[54](IRENA, 2015)
[55](ACERA, 2018)

Table 6: Intraday and Seasonal Supply Blocks in Chile	
Results	The competitive procurement successfully contracted the hourly and quarterly electricity requirements of distribution companies. Awarded bids, all of which are backed by new RE projects, will provide continuous power within the defined block at an average cost of 3.25 cents/kWh (2.24 INR/kWh) – the lowest price ever recorded in the country. As a reference, the average spot market price in 2017 was considerably higher at roughly 5.51 cents/kWh and 5.74 cents/kWh[56] (3.8 INR/kWh and 3.98 INR/kWh). Bids from solar projects were the most competitive at 2.15 cents/kWh (1.49 INR/kWh), followed by wind at 3.29 cents/kWh (2.28 INR/kWh), to be commissioned by 2024. This result allows distribution companies to receive electricity at a lower cost than with thermal technologies, which had the second highest average bid prices submitted at 7.54 cents/kWh (5.22 INR/kWh), after biomass at 7.79 cents/kWh (5.4 INR/kWh). Bids from solar with battery storage averaged 3.65 cents/kWh (2.53 INR/kWh). Although a very competitive result, these bids were not awarded due to restrictions specified by the bidders. Competitive procurement effectiveness will also depend on the timely commissioning of the contracted projects and the actual delivery of electricity in the defined blocks. The six-year project realization period means projects need to be commissioned by January 2024. Therefore, an assessment of the project's success or failure currently is not possible.

CONSIDERATIONS FOR APPLICATION IN INDIA

Advantages:

- Time-based incentives help matching RE generation with the demand curve, thus avoiding an inefficient and costly capacity addition pathway for utilities.
- Price adjustment factors offer financial compensation to RE producers for optimizing a supply that meets the demand profile.
- Supply blocks limit the supply timeframe to times-of-day/year-specific demand and therefore:
    - Increase long-term revenue certainty of producers compared to spot-market price risk (where spot markets exist).
    - Encourage intermittent RE generation to provide reliable electricity by limiting to a timeframe of the day or year in which the supply block is more compatible with the installation's generation profile.

[56](CNE, 2018)

Disadvantages:

- Compared to the wholesale market, time-based incentives increase the risk of overcompensating RE electricity that will be less valuable in a few years.
    - This design fixes time-based incentives for the long-term. Changing supply and demand profiles might require a different type of time-incentive over the plant lifetime. Adapting supply blocks and volume regularly could mitigate the risk of future mismatch between generation and demand profiles. For example, DISCOMs could conduct power system modeling that accounts for the projects awarded in a procurement round and their feed-in profile, to determine the demand required in the next round and whether the supply block is still adequate.

3.2 GLOBAL TREND 2: AGREGGATOR (VIRTUAL HYBRIDS)

DESCRIPTION

Aggregators, or virtual hybrids, refer to RE installations at different grid connection points, which are bundled and dispatched via virtual control systems. Virtual hybrids, like a control center, aggregate electricity from several generators and feed in as much electricity as has been purchased.

Other types of aggregation refer to the bundling of buy offers from distribution companies and sale offers from RE producers. In Chile, the regulator collects demand projections from distribution companies and conducts the RE procurement.

The focus of global Trend 2 is on virtual hybrids.

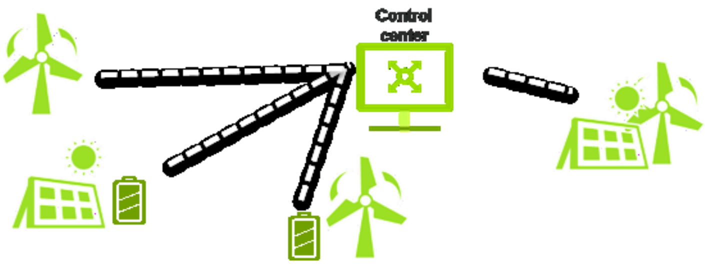

Figure 2 - Simplified representation of a virtual hybrid

COUNTRY EXPERIENCE

The virtual power plant (VPP) Next Kraftwerke in Germany bundles intermittent RE in a portfolio to provide flexibility services in the market. Hybrid solutions with storage create a quasi-dispatchable virtual power plant.

Table 7: Virtual Power Plant Next Kraftwerke in Germany	
Objective	Integrating smaller intermittent RE to provide balancing energy products to the balancing market.
Design	Since 2012, RE producers can offer balancing energy on the balancing energy market in Germany. The products are procured in daily and weekly competitive procurement rounds by the grid operator. The products procured are primary reserve (delivered within 30 seconds), secondary reserve (delivered within 5 minutes), and tertiary reserve (delivered within 15 minutes and up to 1 hour). Next Kraftwerke's virtual hybrid digitally aggregates multiple (small and large) RE and conventional installations operated by different producers into a single centralized control system. Different generation technologies (e.g., solar PV, wind, hydro, biogas, and combined-heat-and-power (CHP)) and power consumers are bundled to offset intermittency risks. The asset aggregation allows them to be forecasted, optimized and traded as one single power plant. Fluctuations in the generation of RE can be balanced by ramping up and down power generation and power consumption of controllable units. Moreover, RE can be better integrated into existing markets, since smaller, individual plants can in general not provide balancing services or offer their flexibility on the power exchange. Installations wishing to participate in the balancing market need to be prequalified, i.e., technically and functionally checked for complying with the transmission code. In case of a frequency imbalance, the virtual hybrid receives an order from the grid operator requesting a certain amount of power to balance out frequency deviations. The call is divided into smaller parts, since the individual assets of the virtual hybrid can only provide a fraction of the needed power. The algorithm of the virtual power decides which asset will provide how much power. The revenues earned in the balancing market are shared between the virtual hybrid and the RE producers.
Results	As of 2016, Next Kraftwerke provided aggregated power of 67 MW as primary reserve, 67 MW as secondary reserve, and 1160 MW as tertiary reserve[57], thereby reducing the provision of these products by thermal generation. This includes biogas, hydro, emergency aggregators (using diesel) and CHP plants.[58]

CONSIDERATIONS FOR APPLICATION IN INDIA

Advantages

- Virtual hybrids offer the possibility to sign shorter contracts with DISCOMs/institutional buyers. This results in prices better adapting to changing demand needs and RE market prices.
- Virtual hybrids bundle RE generation assets in different locations and with different profiles, enabling the compliance with time-specific generation requirements.

[57](Next Kraftwerke, 2016)
[58](Next Kraftwerke, n.d.)

Disadvantages

- The business case for virtual hybrids to, for example, provide balancing services depends also on the compensation, which is usually organized via an ancillary services market. This type of market has not been implemented so far in India. All generators with regulated tariffs must keep a reserve, yet the current market for balancing services is not open for private players.
- The competitiveness of virtual hybrids in RE procurement depends on a portfolio that combines shorter and longer contract durations. If the portfolio is composed of shorter contracts, cost-covering bids from virtual hybrids will likely not be successful, especially given the current priority in contracting the lowest offered price in RE procurement.
- Compared to physical hybrids, virtual hybrids do not lead to lower grid connection costs per each RE asset.

3.3 GLOBAL TREND 3: PROCUREMENT OF (PHYSICAL) HYBRID SOLUTIONS

DESCRIPTION

Technologies such as wind, solar and potentially storage aim to combine complementary generation profiles to offset technology-specific intermittencies and provide a more continuous power supply. Moreover, physical hybrids allow for a more efficient use of land and transmission infrastructure compared to single-technology installations given that energy generation per unit area of land and evacuation infrastructure can be increased.

Hybrid solutions may integrate storage applications such as pumped hydro and batteries, as well as dispatchable RE such as bioenergy. In this context, solar-wind hybrid solutions already used in India tap in the daily and seasonal feed-in complementarity of solar and wind resources[59]. The combined generation feed-in becomes more dispatchable compared to single technology. Storage solutions also level single wind or solar generation patterns and help to balance out forecast errors in generation at the power-plant level.

COUNTRY EXPERIENCE

Table 8: Con Edison, NY – Brooklyn Queens Demand Management Program	
Objective	Contracting of-demand and supply services to manage future loads and avoid distribution grid investments. To avoid over $1.2 billion (INR 83.2 billion) of investments in the distribution network—notably the construction of an additional substation for the Brooklyn and Queens area—Con Edison implemented the competitive procurement of generation- and demand-side resources with a budget of $0.2 billion (INR 13.9 billion).
Design	Competitive procurement in 2016 targeted the contracting of resources for load reduction in the 4-8pm and 8pm-12am summer season time windows, for 2017 and 2018. Undisclosed ceiling prices were defined at $250/kW/year (INR 17,337.8) for the 4-8pm window, and $1,250/kW/year (INR 86,688.8) for the 8pm-12am window. For 2018, these prices were increased to $750/kW/year (INR 52,013.3) for the 4-8pm window and kept same for the 8pm-12am window. The process started with ceiling prices, against which bidders will lower their bid until volume demanded was met (descending-clock auction).

[59](PACE-D, 2017)

Table 8: Con Edison, NY – Brooklyn Queens Demand Management Program	
	Revenue sources for awarded projects consist of an availability payment equivalent to the clearing price of the auction (uniform pricing) and a performance payment for planned events of $5 (INR 346.8) per kilowatt-hour reduced for each event. The existing restrictions on emissions meant that, de facto, no diesel generators or gas turbines could be selected.
Results	The competitive procurement contracted ten bids for a total of 22 MW of resources to cover peak demand and avoid distribution grid investments. While the final results of the program, which includes other customer- and utility-side measures, continue to be monitored, the projected net benefits of the program were $94.9 million resulting from delayed substation/transmission investments and load transfers from 2017 to 2026[60]. All of the awarded bids corresponded to demand response programs (six by storage and four by providers of demand-side management). Generation technologies were not successful due to limited land availability in this densely-populated area and construction lead time before operation deadline. A substantial part of the awarded quantities, however, was not implemented: 66% of the contracted quantities in 2017 and 84% of contracted quantities in 2018 were not delivered. Reasons for non-delivery cited by bidders include limited time between the award of the projects and the operation deadline and lack of clarity in the permitting process[61] for battery projects, which required the approval by the municipal fire department[62].

Ceiling Prices and Results for the Con Edison 2016 Brooklyn Queens Demand Management Program[63]

Year of Delivery	Time Window	Ceiling Price	Clearing Price	Contracted Quantity (kW)	Delivered (kW)
2017	4pm-8pm	$250	$214.62	2,150	3,940
2017	8pm-12am	$1250	$984.50	9,371	
2018	4pm-8pm	$775	$449.56	5,995	3,610 kW
2018	8pm-12am	$1,250	$987.99	16,692	

[60](Girouard, 2019)

[61] The time required to process permitting documentation for batteries is often longer than the time required for other technologies. Accordingly, Con Edison adjusted the deadlines for permitting documentation based on technology for its 2019 BQDM Extension Auction. (Con Edison, 2018)

[62](Con Edison, 2017)

[63](Con Edison, 2017)

Table 9: Hybrid Procurement for Firm Energy in Thailand	
Objective	Ensure a continuous supply of electricity even during peak hours, reduce intermittency of RE generation. The hybrid PPA scheme was introduced by Thailand's Ministry of Energy in 2017 to increase energy security.
Design	The hybrid PPA schemes targets projects between 10 and 50 MW of RE capacity that can guarantee a certain level of continuous supply in peak demand periods. The ceiling price was 11.09 cents/kWh (7.69 INR/kWh), consisting of a fixed component feed-in tariff FIT_f of 5.48 cents/kWh (3.80 INR/kWh) and a variable component FIT_v of 5.61 cents/kWh (3.89 INR/kWh in 2017). Bidders offered discounts on the ceiling price. The tariff paid to awarded projects is the discounted tariff offered by bidders adjusted for inflation.[64] Eligible bidders need to guarantee the following delivery of electricity: • Peak: 100% contracted capacity, ± 2% tolerance range (Monday-Friday, 9am-11pm) • Off-peak: 65% of contracted capacity, ± 2% tolerance range (at all other times) Non-compliance triggers a penalty of roughly 1.10 cents/kWh (0.76 INR/kWh), equivalent to 20% of the fixed tariff FIT_f component of 5.48 cents/kWh (3.80 INR/kWh) The hybrid scheme was technology-neutral but only open to RE technologies. Natural gas can only be used in the start-up process of a power generator, but coal is not allowed to participate. There are also no restrictions on the types of RE technologies or a minimum number or share of RE technologies which may be used. 300 MW of RE capacity were split into nine regional quotas. If the capacity in a region is not exhausted, the surplus will be awarded to projects in other regions if they offer the lowest prices and if there is available grid capacity.
Results	The hybrid scheme round of 2017 awarded 300 MW to firm RE technologies that will provide off-peak power at 7.39 cents/kWh (5.13 INR/kWh), which would otherwise be provided by thermal power plants. As a reference, the wholesale or grid parity tariff[65] in Thailand in 2018 was roughly 8.00 cents/kWh (5.55 INR/kWh).[66] Though grid stability due to RE generation has not yet become a major issue in Thailand, the procurement of firm capacity is regarded by the government as a precautionary action to increase the uptake of RE and manage variability in the power system.[67] The average price of 7.39 cents/kWh (5.13 INR/kWh) represented a 33% discount on the ceiling price. Most of the awarded projects were biomass, bagasse and woodchip—all of which are still abundant in Thailand. The lowest-price bidders

[64](OERC, 2018)
[65] The wholesale tariff corresponds to the tariff at which the state-owned utility EGAT sells electricity to the distribution companies, MEA (Metropolitan Electricity Authority) and PEA (Provincial Electricity Authority).
[66](Solar Magazine, 2019)
[67](IRENA, 2017)

Table 9: Hybrid Procurement for Firm Energy in Thailand	
	were the sugarcane producers that have their own fuel supply as a by-product used for power generation. The scheduled commissioning of projects is December 2021.

Results for Thailand's 2017 Hybrid Procurement[68]

Volume Auctioned (MW)	Volume Offered (MW)	Ceiling Price	Average Price	Price per RE Type	Awarded Volume per RE type (MW)
300	755	11.09 cents/kWh (7.69 INR/kWh)	7.39 cents/kWh (5.13 INR/kWh)	Biomass: 7.21 cents/kWh (5.00 INR/kWh)	Biomass: 258.69
				Biogas + solar: 8.73 cents/kWh (6.05 INR/kWh)	Biogas + solar: 16
				Biomass + solar: 8.30 cents/kWh (5.75 INR/kWh)	Biomass + solar: 13.21
				Solar + storage: 7.70 cents/kWh (5.34 INR/kWh)	Solar + storage: 12

CONSIDERATIONS FOR APPLICATION IN INDIA

Advantages

- More efficient use of land and RE resources. Energy generation per unit area of land would be significantly higher compared to wind- or solar-only installation. The capacity utilization factor (CUF) for a hybrid plant is also better than a single-technology solar plant. For example, USAID estimated a hybrid installation in Karnataka can reach a CUF of 36.3% compared to a CUF of 18% for just single-technology solar PV.[69]
- Savings on grid connection and transmission cost since time-of-day generation patterns of wind and solar can be complimentary. Reducing costs by using a common grid connection infrastructure is critical in India since point-of-connection charges for inter-state power transmission are high, and the waivers granted for RE expire in 2019.[70]
- A more balanced power mix for sale, given that solar generation peaks at around noon (between11am and 2pm), while wind generation usually increases in the afternoon (starting 4pm until 2am).[71] Wind generation also increases during late summer and the monsoon season while solar drops because of clouds or high temperatures. The result is a lower peak-to-average power for the same hour throughout the year than for single-technology wind or solar plants.[72]

Disadvantages

- A correct parametrization of design elements for competitive procurement is more complex than in single-technology procurement. Wind and solar typically have different project

[68](OERC, 2018)
[69](USAID, MNRE, 2017)
[70](USAID, MNRE, 2017)
[71](Agrawal, Khemka, Manoharan, Jain, Mukhopadhyay , 2016)
[72](USAID, MNRE, 2017)

development durations, including permitting times, capacity factors and cost structures that need to be considered.

- Grid connection and transmission costs are not yet reflected by the bids submitted by bidders. If no grid connection costs and part of transmission costs need to be assumed by the RE producer, higher prices will be seen in hybrid procurement compared to single-technologies given that grid cost savings in hybrids will not be reflected. Higher bid prices under these conditions could therefore discourage DISCOMs from procuring hybrid installation given for some their overcapacities and interest in low tariffs.

3.4 GLOBAL TREND 4: LOCATIONAL SIGNALS

DESCRIPTION

Site-agnostic procurement schemes tend to concentrate the development of RE projects to RE resource-rich locations, which can burden the grid infrastructure and create competition for land usage. Locational signals aim at steering the location of projects to specific areas/grid connection points to avoid the concentration of projects in resource-rich but costly-to-connect areas. Figure 3 shows different ranges of locational signals. They include a bonus/penalty for bids located in areas with available/insufficient grid capacities (e.g., Germany, Mexico), RE development zones with simpler permitting processes (e.g., South Africa), capacity quotas at regional or grid connection point level (e.g., Kazakhstan) or site-specific competitive procurement (e.g., Zambia).

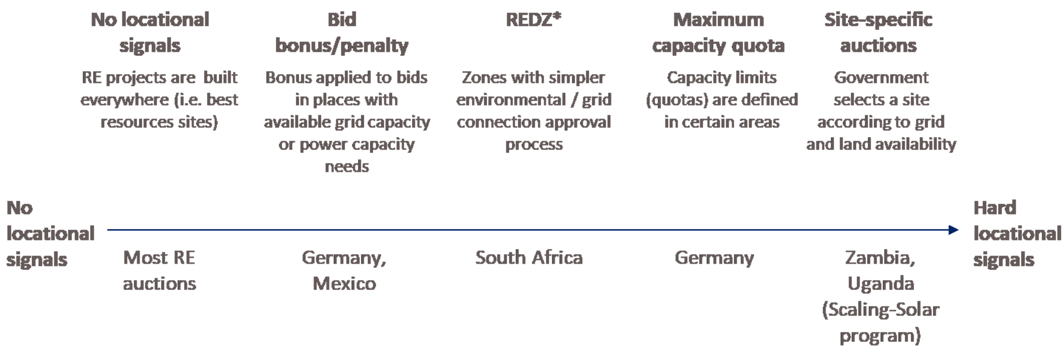

Figure 3 - Competitive procurement and range of locational signals

The signal given by these mechanisms can be at price (price-based) or quantity (quantity-based) level. If designed perfectly, quantity (capacity quotas, site-specific competitive procurement) and price-based (bonus/penalty) control mechanisms would lead to the same auction result, that is, bidders with the lowest total cost will be awarded.[73]

[73] (Kreiss, Ehrhart, Haufe, Rosenlund Soysal, 2018)

COUNTRY EXPERIENCE

Kazakhstan implemented capacity quotas to limit transmission costs from auctioned installations and ensure the system can absorb the additional generation capacity.

Table 10: Capacity Quotas in Kazakhstan	
Objective	Capacity quotas were set at multiple nodes of the system to minimize new transmission costs and ensure the system could absorb the electricity generation resulting from the auction. The Kazakhstan power system has surplus generation capacity.
Design	The auction documents contain information on the land plots allocated for the construction of an RE installation and grid connection points indicating the maximum permissible capacity and the number of possible connections. The grid connection points are provided by the transmission grid operators to the Ministry of Energy and are reserved until the winning bidders conclude a grid connection agreement. Bidders also need to specify the minimum permissible volume of installed capacity for their installation with their bid. If the volume of bids exceeds the maximum permissible capacity at this connection point, bids will be excluded from the preliminary list of winners in the descending order of prices until the maximum permissible installed capacity for the connection point is met. A partially satisfied bid, that is, a bid whose capacity is only partly covered within the maximum permissible capacity, will be awarded if the reduced volume of partially satisfied bids is greater than or equal to the minimum permissible volume of the bid.
Results	The competitive procurement in Kazakhstan contracted 857.93 MW of RE projects that will be located at nodes with sufficient grid capacities and so can help minimize the need for grid expansion presents a summary of the results and the planned commissioning deadline for each RE technology. More than half of the volume awarded went to wind projects (500.9 MW) followed by solar (270 MW), hydro (82.1 MW) and one 5-MW-project for biogas. Lowest awarded bids were for hydro (3.5 cents or 2.43 INR per kWh), wind (4.7cents or 3.26 INR per kWh), and solar (4.9 cents or 3.40 INR per kWh). Seven rounds (out of 20) were canceled because of an insufficient number of participants and offered volume. Public information on how many bids were excluded or partially awarded due to the capacity quotas is not available.

Competitive Procurement Results in Kazakhstan, 2018[74]

Ceiling Price	Awarded Volume (MW)	Weighted Average Price	Commissioning Deadline
Wind:	500.85	Wind: 5.06 cents/kWh	Wind: 3 years after PPA

[74](USAID, 2018)

Table 10: Capacity Quotas in Kazakhstan			
6.11cents/kWh (4.28 INR/kWh)		(3.51 INR/kWh)	
Hydro: 4.5 cents/kWh (3.12 INR/kWh)	82.08	Hydro: 3.86 cents/kWh (2.68 INR/kWh)	Hydro: 4 years after PPA
Solar: 9.33 cents/kWh (6.47 INR/kWh)	270	Solar: 5.52 cents/kWh (3.83 INR/kWh)	Solar: 2 years after PPA
Biogas: 8.69/kWh (6.03 INR/kWh)	5	Biomass: 8.67cents/kWh (6.01 INR/kWh)	Biomass: 3 years after PPA

CONSIDERATIONS FOR APPLICATION IN INDIA

Advantages

- Locational signals, compared to location-agnostic competitive procurement, seek to reduce total system costs by identifying an optimal trade-off between required grid extensions/reinforcements and RE generation costs.
- Even if the system cost difference between RE deployment with and without system-friendly procurement should be low, there is still an argument for locational signals for their potential in allowing a faster deployment (e.g., Texas Competitive Renewable Energy Zones or Germany's wind offshore zones).
- Locational signals help to reduce the need for short-term grid extensions, particularly of advantage if there are strong barriers to grid extension. India currently faces important grid constraints at the transmission level, which lead to congestion and curtailment. The CEA estimates INR 2.69 trillion ($39 billion) of investment are needed at the transmission level by 2022 to build 110,000 circuit kilometers (ckm) of transmission lines and about 383,000 MVA of transformation capacity in the substations at the 220kV-level and above.[75] Congestion in transmission caused a loss of 3.1 GWh of electricity on the Indian Energy Exchange in 2014-15 or the equivalent of New Delhi's consumption.[76]

Disadvantages

- Compared to competitive procurement without locational signals, procured prices might be higher when locational signals are applied. The latter aim to minimize system costs, while the former focus only on generation costs at project level.
- Sources of error influence the effectiveness of locational signals. These might include missing resources and information among the authorities designing procurement schemes. For site-specific competitive procurement, a lack of resources and tight deadlines have led to errors in site preparation and delays in the process implementation timeline. In the case of capacity quotas and bid bonus/malus, a lack of oversight of the whole system can lead to the definition of inadequate limits. The grid operator needs to have knowledge of connection conditions and available capacity for each node, and timely communicate this to the procuring entity.

[75](Bajaj, 2019)
[76](India Times, 2015b)

4. RECOMMENDATIONS

This white paper is intended to stimulate conversation on system-friendly RE procurement in India, based on an analysis of Indian procurement practices and selected global trends aiming at better integration of RE generation. It has presented how system-friendly RE can support a higher uptake of REby moving away from only minimizing generation costs to minimizing both generation and system integration costs. This section concludes with recommendations, presenting brief actions for procuring institutions when improving the supply and demand match through dispatchable RE, mitigating grid integration/transmission costs, and reducing intermittency.

Building on its 2018 national wind-solar hybrid policy, guidelines by the MNRE for hybrid and system-friendly RE procurement could further address these steps and inform procuring entities, states and DISCOMS on policy design options.

RECOMMENDATION 1: CONTINUE TO DEVELOP GUIDELINES TO SUPPORT RE DELIVERED AT LEAST COST INSTEAD OF RE GENERATED AT LEAST COST

The draft guidelines on wind-solar hybrid competitive procurement issued by MNRE in October 2019 represent an important step in the support of state and central-level procuring entities. Indeed, the guidelines aim to address some of the challenges identified by the private sector by: giving RE producers flexibility to adjust the CUF during the first three years of operation; allowing states to define their own ceiling price; and requiring bidders to provide evidence of project development with their bids. However, RE grid integration and transmission costs are still not considered in RE procurement. In price-only RE procurement without spatial limitations, the (socialized) costs of connecting distant RE plants to the grid can outweigh the cost advantage of using the best RE sites. In addition, DISCOMs/states' preference for procurement of RE generated at least cost, dominated by solar, is resulting in "solar crowding" without considering the effective cost of delivery of the solar power.

Furthermore, physical RE hybrid projects currently do not receive compensation for their lower interconnection costs due to RE generation at higher CUF as the grid connection charges are socialized. With the expiration of the waiver of the grid connection charges for RE projects in 2019, lower grid connection costs of physical RE hybrids would make the hybrids more competitive compared to single-technology RE plants.

Emphasis must be placed on RE procurement at least delivered cost that will benefit in overall savings and promote system friendly RE projects. This can be achieved by revising the regulatory provisions associated with the exemption of RE grid integration and transmission costs. Further developing model procurement documents will enable implementation of system friendly RE projects. Again, the recent draft guidelines by MNRE are a positive step in this direction, which can be further developed by offering guide documents on how to define specific design elements such as ceiling prices and bidding parameters to procure RE power that is less intermittent or guaranteed during specific hours of the day.

Potential agencies to undertake regulatory revisions can include CERC, State Electricity Regulatory Commissions (SERCs) and FoR. A model procurement document can be developed by SECI, MNRE and FoR.

RECOMMENDATION 2: DESIGN TENDER DOCUMENTS TO ALLOW FOR RE PROCUREMENT WITH TIME-BASED INCENTIVES AND SUPPLY BLOCKS TO PROMOTE DISPATCHABLE RE

Growing evening peaks require RE to be more dispatchable, but there is lack of incentives for dispatchability. Time-based incentives need to reflect evolving energy demand by DISCOMS. Procuring institutions should base demand forecasts on resource planning and assess to what extent evening peak could be covered by dispatchable RE and storage (time, magnitude, seasonal variability of peak). Success of RE procurement based on intra-day and seasonal time blocks has already been demonstrated in Chile (see Section 3).

Time responsive and dispatchable RE could be aligned to a liquid wholesale market generating time-specific price incentives. This will increase the accessibility for RE in wholesale market including centralized day-ahead scheduling and real-time dispatch.

The tender documents can be developed by RE procuring agencies such as SECI, DISCOMs and state procurement agencies. This can include bulk consumers of power such as Indian Railways and Delhi Metro Rail Corporation (DMRC).

RECOMMENDATION 3: DESIGN PROCUREMENT GUIDELINES TO PROMOTE STRONG LOCATIONAL SIGNAL FOR RE

Locational signals should be designed to optimize RE project location and development and reflect an optimal trade-off between system benefits, such as reduced grid extensions/reinforcements and RE generation costs. When designing locational signals, procuring institutions can quantify the appropriate signal through the application of a detailed production cost model, which optimizes dispatch of the power system while considering transmission grid constraints.

Locational signals can be included by RE procuring agencies such as SECI, DISCOMs and state procurement agencies and informed by transmission assessments by POSOCO and state transmission system operators.

RECOMMENDATION 4: RECOGNIZE THE VALUE OF FIRM RE POWER SUPPLY

Intermittent RE power increases the need for balancing and associated balancing costs. Balancing needs can be addressed through system-friendly RE procurement designs. Physical RE hybrids provide a more stable supply through offsetting technology-specific intermittencies. Virtual hybrids (aggregators) can bundle and dispatch even distant RE plants for balancing and time-based incentives favor the inclusion of storage.

The value of balancing RE, however, is not sufficiently compensated currently. The procuring entity should assess the need for lower power intermittency from RE plants, e.g., through higher associated balancing costs and assess to what extent complementary solar and wind profiles and batteries reduce this intermittency. Incentives for virtual, dispatchable hybrids depend on the power system design. Here MNRE could introduce either stricter forecasting deviation responsibilities for RE plants or a balancing market for additional revenue streams for balancing RE plants.

Similarly, SECI, DISCOMs and state procurement agencies can facilitate a less intermittent RE generation by compensating storage and by separate procurements for more stable physical RE hybrids.

RECOMMENDATION 5: TAILOR RE PROCUREMENT DESIGN TO REGIONAL CONDITIONS

Nation-wide uniform procurement design favors RE projects at the nation's best sites and concentrates RE projects there, preventing a more balanced distribution among states. Differentiated procurement design across technologies and locations tackles this problem and reduces the risk of geographical concentration.

For physical RE procurement, setting a uniform and ambitious CUF and ceiling prices across states, which would be only achievable in regions with higher RE resource potential, can either restrict the number of participating bidders or risk the non-completion of awarded projects.

SECI, DISCOMs and state procurement agencies should consider different ceiling prices across states or regions with different RE resources and take seasonal RE generation patterns (e.g., months with very low wind generation) into account when setting the capacity utilization factor.

RECOMMENDATION 6: ENGAGEBIDDERS EARLY TO MINIMIZE RE PROCUREMENT UNDERSUBSCRIPTION

The RE procurement cycle in India is often is long due to repeated date extensions when an insufficient number of bids is received. Reasons for lack of bidder interest are often due to requirements that are unrealistic for the region (e.g., a too low ceiling price or to high minimum CUF). Understanding barriers and bidder concerns is important to ensure a high and balanced competition. Prior consultation with the bidders, lenders, and industry expert helps to alert procuring institutions on potential pitfalls and to create a bankable process. Publishing the draft and final versions of tender documentation increases transparency in the process. Engaging with the grid operator and permitting authorities at the state/national levels in the early stages of the design process can support setting to realistic implementation timelines. Defining a policy roll-out timeline allows stakeholders to raise red flags in implementation that, if left unaddressed, could lead to delays or failure of RE deployment and help developers to adjust.

All procuring agencies (SECI, DISCOMs and state procurement) should facilitate the engagement process, bidder, investors and industry associations should actively and vocally participate.

THE WAY FORWARD

In the coming months, PACE-D 2.0 RE will continue the discussion and advice on the design of system-friendly RE procurement regulations through activities such as the design of a competitive bidding framework, support a partner institution with procurement and recommend regulations supporting system integrations. We will closely align with relevant stakeholders and we encourage feedback and ideas on this white paper.

ANNEX

Table A. - Overview of selected competitive procurement for hybrids in India

Year	Procuring entity	Technology	Volume	Status	Location
2018[77]	SECI	Solar PV + wind	1200 MW	Completed	India
2019[78]	SECI	Solar PV + wind	1200 MW	Completed	India
2018[79]	NTPC	Solar PV + wind	190 MW	Announced	Karnataka
2019[80]	SECI	Solar PV + storage	1200 MW/3600 MWh	Announced	India
2019[81]	SECI	Solar PV + storage	200 MW/300 MWh	Cancelled	Andhra Pradesh
2019[82]	SECI	Floating solar + battery storage	20 MW/60 MWh	Announced	Lakshadweep
2018[83]	NTPC	Solar PV + storage	17 MW/6.8 MWh	Completed	Andaman and Nicobar Islands
2018[84]	NTPC	Solar PV + storage	8 MW/3.2 MWh	Completed	Andaman and Nicobar Islands
2018[85]	SECI	Solar-Wind hybrid + optional storage	160MW	Completed	Andhra Pradesh
2018[86]	NLC	Solar PV + storage	20 MW/8 MWh	Completed	Andaman and Nicobar Islands
2019[87]	SECI	Solar PV + storage	14 MW/42 MWh	Announced	Jammu and Kashmir
2019[88]	SECI	Floating solar	150 MW	Announced	Jharkhand
2019[89]	SECI	Floating solar	250 MW	Announced	Tamil Nadu
2018[90]	SECI	Floating solar	150 MW	Completed	Uttar Pradesh
2018[91]	NTPC	Floating solar	100 MW	Completed	Telangana
2018[92]	NTPC	Floating solar	70 MW	Completed	Kerala
2019[93]	MSEDCL (DISCOM)	Floating solar	1000 MW	Completed	Maharashtra

[77](Prateek, 2018b)
[78](India Times, 2019)
[79] (Renewables Now, 2018)
[80](Kabeer, 2019a)
[81](Kenning, 2019)
[82](Dutta, 2019)
[83](Gulia, 2019)
[84](Gulia, 2019)
[85](Kabeer, 2018a)
[86](Prateek, 2018c)
[87](Kabeer, 2019b)
[88](Solar Chronicle, 2019)
[89](Prateek, 2019c)
[90](Kabeer, 2018b)
[91](Kabeer, 2018c)
[92](Kabeer, 2018d)
[93](Kabeer, 2018e)

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