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Prospects and Challenges for India delivering on Renewable Electricity Generation Targets

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1. Introduction

India is in the midst of an unfolding energy transition which in turn comprises three sub-transitions. First, a power sector transition which is a shift from fossil-fuel-based electricity generation to renewable energy (RE) based generation. Second, a mobility transition, a shift away from petrol and diesel-powered vehicles to electric vehicles (EV). Third, an industrial transition which is a shift away from fossil-fuel-powered industrial processes and manufacturing to that powered by clean sources such as green hydrogen. Each of the three sub-transitions is unfolding in parallel but at different phases of evolution.

40% of India's emissions are traceable to electricity generation (MoEFCC 2021; Gulagi et al. 2022). An orderly transition of the power sector, therefore, lies at the heart of the country's decarbonisation efforts. Increasing the penetration of RE, and a calibrated phase down of thermal power, are the twin facets of orderly power sector transitions in most countries. India is no different. Specifically, on the former, India has set itself ambitious targets for RE, which have progressively evolved over time. So just how do we achieve these targets? What will it take? Answering these questions requires a clear understanding of the current state of play with respect to RE, as well as the evolution of RE targets themselves.

2. State of play & RE target evolution

Solar, wind and hydro are the three principal constituent elements of India's installed RE generating capacity. At 165 GW, RE accounted for 40.5% of India's total installed electricity generating capacity as of September 30, 2022(CEEW CEF 2022c).

On the other hand, RE's share of generation is significantly lower. This is due to the lower power plant load factors (PLF) that both solar and wind operate under. However, there is also a great deal of seasonality and inter-day variability in RE's generation share. Table 1 below summarises the contribution of RE both from a share of installed generating capacity, as well as from the perspective of share of generation.

Table 1: RE share of generating capacity & generation

	Share of Installed Generating Capacity	**Share of Generation**		
	(as on 31 March 2022)	(for FY 22 ending 31 March 2022)		
		Average Daily	Hi (date)	Lo (date)
RE (excluding Hydro)	26.9%	10.8%	19.2% (8 August 2021)	7.0% (23 December 2021)
RE (including Hydro)	39.2%	22.3%	38.6% (31 July 2021)	13.8% (12 April 2021)

Source: CEEW-CEF Analysis based on data published by Central Electricity Authority (CEA)

So, what has India's journey been like to get to where it is today? Target setting has played an important facilitating role, evolving to reflect ever-heightened ambitions. Table 2 below summarises the manner in which these targets have evolved over time.

Table 2: RE target evolution

	Target (Description)	**Target** (Year)	**Comments**
January 2010 (PIB 2010)	20 GW grid solar capacity 2 GW off-grid capacity 20 million sq.m. solar thermal collector area	**2022**	Jawaharlal Nehru National Solar Mission (JNNSM) which focused on the development of the solar energy sector (given that as of FY2010, an appreciable wind capacity of 10.7 GW was already installed).
February 2015 (PIB 2015)	175 GW 100 GW solar 60 GW wind 10 GW bio-power 5 GW small hydro-power	**2022**	Solar target under JNNSM revised to 100 GW with 40 GW from rooftop solar projects. Specific targets for other RE were also introduced.
September 2019 (PIB 2019)	450 GW of RE	**2030**	Announced at United Nations Climate Action Summit in New York.
November 2021 (PIB 2021)	500 GW of non-fossil energy capacity 50% of energy requirements from RE	**2030**	Announced in Glasgow during COP26.
August 2022 (PIB 2022b)	50% cumulative electric power installed capacity from non-fossil fuel-based energy resources	**2030**	Cabinet approved NDC submitted to UNFCCC.

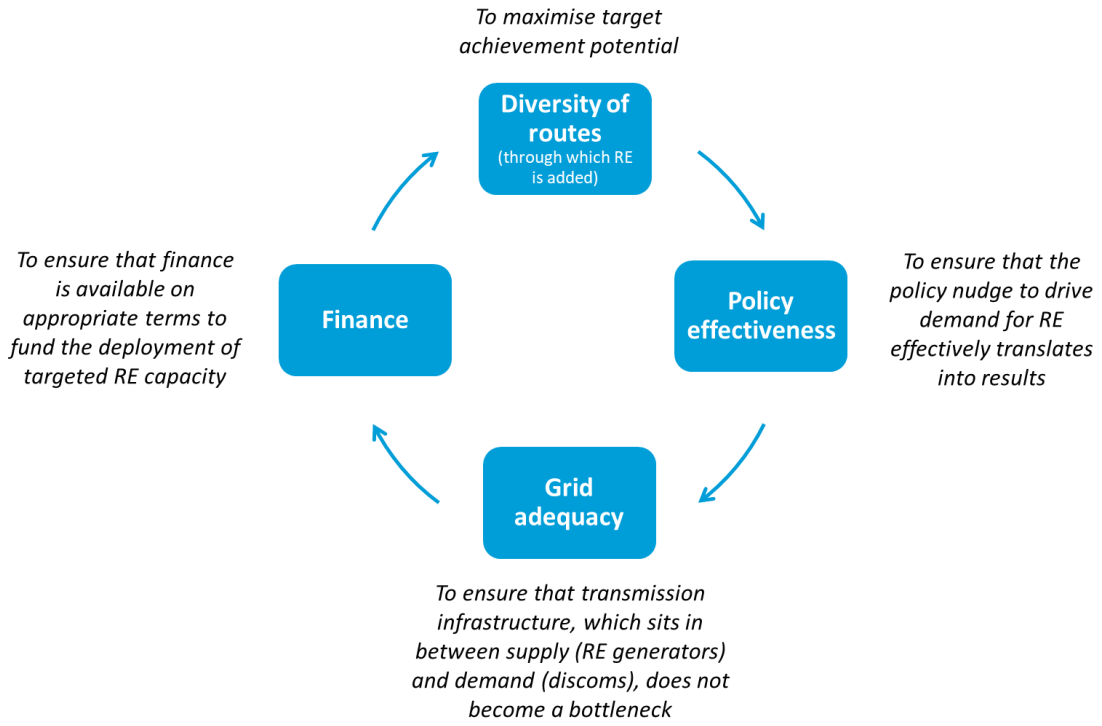
Source: CEEW-CEF analysis based on multiple publicly available data sources

So, while the most recent target of August 2022 does not mention a specific GW figure, this paper approaches the subject through the lens of 500 GW of RE by 2030, being the generally accepted target. This specific GW figure also broadly aligns with a modelling exercise conducted by the Central Electricity Authority and released in a report in 2020 (Central Electricity Authority (CEA) 2020). As such, all references to "target" in this paper should be construed to mean an installed RE capacity of 500 GW by 2030.

3. Delivering on the targets - four key considerations

The overarching reform of India's distribution companies (discoms) is central to building a sound and robust power sector in India. At 60 (PFC 2022a), India has a large number of discoms. This can partly be ascribed to the fact that electricity features as a concurrent subject in the Constitution of India. However, reforming discoms, whose total aggregate technical and commercial (AT&C) losses stand at 22.32% in FY 21 (PFC 2022b), is a highly complex topic in itself. As such, rather than focusing on over-arching discom reform, which is relevant to the health of the power sector as a whole, this paper examines prerequisites that are specific to the achievement of RE targets. In reality, there is a wide spectrum of such prerequisites. Among them, this paper focuses on four which have been highlighted separately by several stakeholders in recent months. These four prerequisites, or key considerations, have been outlined in Figure 1: Four key considerationsbelow. They are interrelated and equally critical to target achievement. Furthermore, the interrelationship implies that an equal and parallel focus is required on each consideration, as failure to deliver on any one can have a cascading effect on the others.

Figure 1: Four key considerations



Source: CEEW-CEF compilation

The Energy and Resources Institute (TERI) pointed out in a discussion paper that while RE growth to date has been attributed primarily to utility-scale projects, unlocking the potential of decentralised RE could contribute significantly to India's targets (Shankar, Saxena, and Idnani 2022). Moving to policy, Moody's Investors Service, in a report, emphasised that continuous policy support from the government is key to India meeting its RE targets (Moody's 2022). On the topic of the grid, CEA highlighted that high transmission capacity is required to evacuate power from RE projects and discussed the grid integration challenges associated with large-scale generation from RE in the draft National Electricity Plan (NEP) (CEA 2022). Finally, on the topic of finance, the Parliamentary Standing Committee on Energy (2021-22) has highlighted the immense investment required for India to meet its 2030 RE targets, pointing out that actual investment flows in recent years have been at most half of what is required (Standing Committee on Energy 2022).

3.1. Five routes to RE capacity addition – state of play

One of the key considerations to achieving India's RE target is to assess the ability of various routes by which RE power is bought, sold, traded or installed to absorb the incremental RE capacity. As almost all the incremental RE capacity is expected to come from variable RE, such as solar and wind (per the modelling exercise referred to in section 2 above), such variable capacities by themselves would need to grow on average at approximately 40 GW per year between now and 2030. Therefore, the question is, what has been the actual growth in variable or non-hydro RE, and how does it measure up against the requirement of 40 GW per year?

3.1.1. Discoms

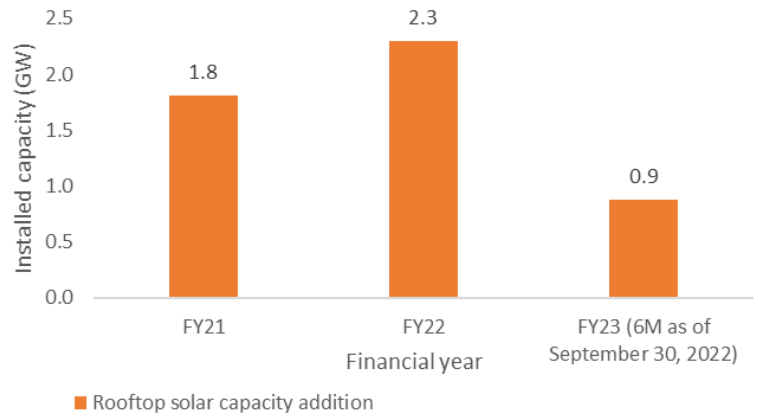
Discoms have traditionally been the dominant procurers of RE (Gandhi, Hoex, and Hallam 2022). Such procurement is either done directly (conducting auctions themselves) or indirectly (via Solar Energy Corporation of India (SECI)/ National Thermal Power Corporation (NTPC) conducting the auctions) by executing power purchase agreements (PPA). In FY 21, FY 22, and FY 23 (6M as of September 30, 2022),

auctioned RE capacity stood at 19.2 GW (CEEW CEF 2021b), 17.5 GW (CEEW CEF 2022a), and 6.7 GW (CEEW CEF 2022b; 2022c), respectively. In other words, despite this route's dominance, it meets less than half of the yearly requirement.

3.1.2. Rooftop solar

A cumulative of 7.5 GW of rooftop solar capacity has been installed to date (MNRE 2022c), lagging far behind the targeted 40 GW of rooftop solar capacity by 2022 (Sarangi and Taghizadeh-Hesary 2021). Importantly, the maximum annual rooftop capacity addition achieved in the last three years has been 2.3 GW. A significant share of rooftop solar capacity (~75%) has been installed by C&I consumers (Das 2022).

Figure 2: Incremental rooftop capacity addition

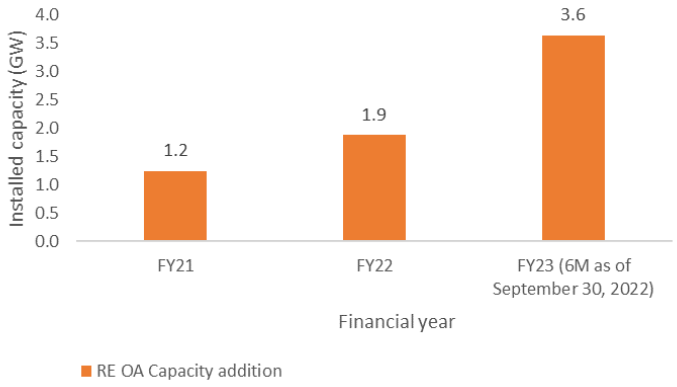


Source: CEEW-CEF compilation based on data published by MNRE

3.1.3. Corporate consumers

Commercial and Industrial (C&I) consumers together represent the single largest source of electricity demand in India. For FY 22, their share of total electricity consumption stood at 36.3% (CEA 2022). With large corporates coming under the ambit of the Business Responsibility and Sustainability Report (BRSR) framework (SEBI 2021), many C&I customers are committing to shift to 100% RE. In doing so, they are turning to RE open access (OA) to fulfil their energy needs at an increasing pace, as depicted in Figure 3 below.

Figure 3: Incremental RE OA capacity addition

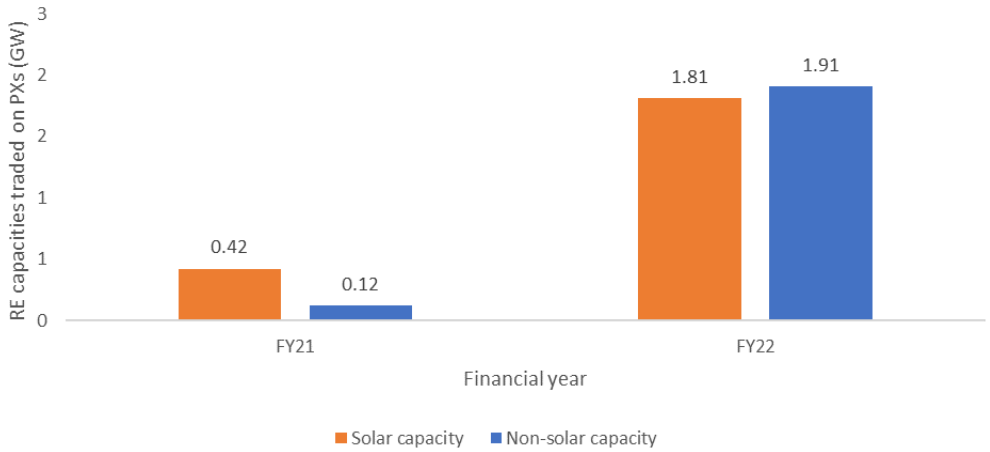


Source: JMK Research

3.1.4. Power exchanges

India has three power exchanges (PXs) – providing a platform for transparent and competitive price discovery. These exchanges are the Indian Energy Exchange (IEX), Power Exchange of India Limited (PXIL) and Hindustan Power Exchange (HPX). Since 2020, two green products, the green term–ahead market (GTAM) and green day–ahead market (GDAM), have been launched. Figure 4 below depicts the underlying installed GW capacity corresponding to the volumes of RE traded in the three PXs. To be sure, the prevailing supply of RE on the exchanges is, to a large extent, sourced from developers and discoms with surplus RE. Even so, this provides an indication of how much this route could absorb if RE capacity were to be installed in a bespoke manner just for trading.

Figure 4: RE capacity (GW) corresponding to green energy volumes (MU) traded on PXs



Source: Author's analysis based on data from CEA's annual market monitoring reports;
Note: calculation assumes non-solar transactions are wind-based only; for kilo-watt hour to kW conversion, CUF for solar and wind are taken at 17% and 22%, which correspond to the minimum CUF requirement in the latest SECI tenders.

3.1.5. Emerging and over the horizon demand

In addition to the routes discussed above, electric vehicles (EV) and green hydrogen (Song et al. 2022) can represent significant incremental sources of demand. The former (EVs) is a rapidly growing space, with EV penetration hitting 6.03% in September 2022. EVs, if charged with RE (Tarei, Chand, and Gupta 2021), can significantly contribute to absorbing the upcoming RE capacities (Ali and Tongia 2018). For example, to fulfil the commitment to the EV30@30 initiative (R. Singh, Ghate, Kulkarni, et al. 2022), 6 Mtoe (CEEW CEF n.d.) of electricity is estimated to be required. This corresponds to ~47 GW of RE.[1] In addition, under the consolidated guidelines and standards for charging infrastructure of EVs, MoP has introduced the feature of time-of-the-day rates and discounts to consumers during solar hours (PIB 2022c)**.** Green hydrogen is somewhat behind as a source of demand. As per the national hydrogen mission, India aims to produce 5 million tonnes of Green hydrogen by 2030, which in turn is estimated to need ~115 GW of RE (Kumar et al. 2022).

3.2. Policies - state of play

3.2.1. Discoms

A number of policies (A. K. Singh and Idrisi 2020) have been put into place to encourage developers to invest in new RE generating capacities on the one hand and nudge discoms to procure increasing quantities of RE on

[1] 1 Mtoe = 11,360 GWh (IEA); further converted into GW by assuming that the electricity requirement is fulfilled by solar energy at 17% CUF.

the other. On the former (supply side), policies such as competitive bidding guidelines (MoP 2010), mitigation of land aggregation risk (MNRE 2014), and getting quasi-sovereigns (NTPC & SECI) to execute PPAs are among the most noteworthy. On the latter (demand side), renewable purchase obligations (RPO) (CEEW CEF 2021a) are mandated for discoms, and a revised trajectory till 2030 was released in 2022 (MoP 2022b).

3.2.2. Rooftop

Under the JNNSM, a target of 40 GW of rooftop solar capacity addition by 2022 was set. At present, phase II (MNRE 2019b) of the programme is under implementation (extended till March 2026) (MNRE 2022d); and it provides central financial assistance (CFA) to residential rooftop solar projects. Furthermore, the central public sector undertaking (CPSU) scheme phase II (government producer scheme) (MNRE 2019a) is under implementation; it provides viability gap funding support to government producers. Finally, most Indian states have adopted a rooftop solar policy (CEEW CEF 2019; A. K. Singh and Idrisi 2020). Most recently, MNRE has proposed group and virtual net metering for rooftop solar projects in rural areas (MNRE 2022b).

3.2.3. Corporate consumers

Through the enactment of the Electricity Act in 2003, the OA route of power procurement first came to life. The Central Electricity Regulatory Commission (CERC) released regulations for OA in inter-state transmission in 2003 (CERC 2003). In July 2022, the Ministry of Power (MoP) recently released green energy OA rules (MoP 2022a) to promote the uptake of RE among corporate consumers.

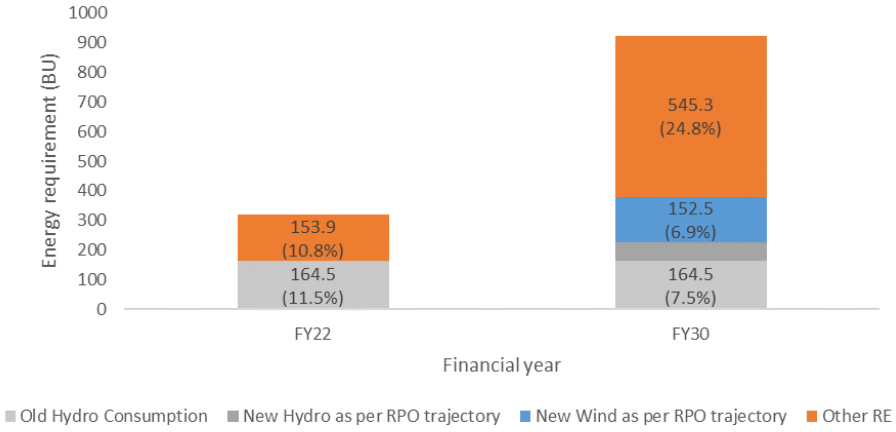
3.2.4. Power exchanges

The Electricity Act 2003 also catalysed the development of a market (including trading) in the power sector. In 2008, CERC granted permission to the Indian Energy Exchange (IEX) and Power Exchange India Limited (PXIL) to set up and operate the PXs, which are regulated under CERC's power market regulations 2021(CERC 2021a). The PXs also host the transactions of renewable energy certificates (RECs) guided by CERC's regulation 2021 (CERC 2022).

3.3. Grid – state of play

As India's installed RE capacity continues to grow, the availability of robust power evacuation and transmission infrastructure will become increasingly critical. There are two key requirements when it comes to transmission infrastructure - adequate transmission capacity to evacuate RE power and ensure power system stability under high penetration of RE scenarios. Per the RPO trajectory, 40.33% of the power purchased by discoms is required to come from RE by 2030. Figure 5 below estimate the share of non-hydro RE in the energy mix in 2030 if that RPO trajectory were to be met.

Figure 5: Share of non-hydro RE in the total generation mix

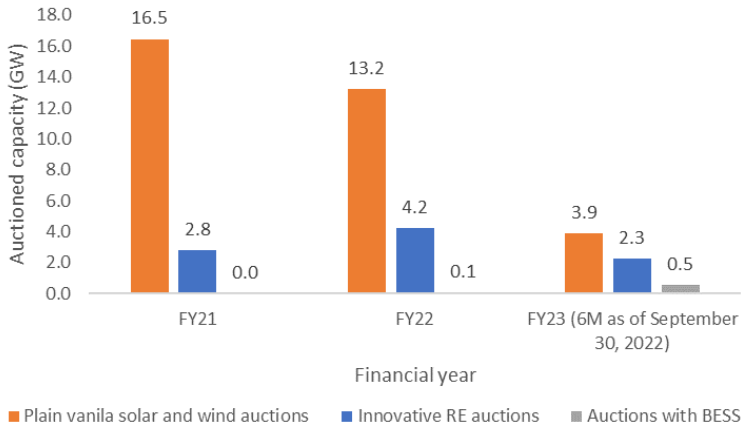


Source: Author's analysis based on India's RPO trajectory (2030) and the data from the 20th electric power survey of India;
Note: For calculation purposes assuming that energy generated is equal to the energy consumed, i.e. no transmission and distribution losses are taken. Actual energy generation numbers are used for FY 22, and the total energy required estimates for FY 30 are taken from the 20th electric power survey of India.

To address the power evacuation and transmission infrastructure adequacy issue, under the green energy corridor (GEC) scheme, dedicated infrastructure for evacuation and transmission of RE power in RE-rich states is under implementation. In phase-I of the scheme, infrastructure to evacuate and transmit ~24 GW of RE is in various stages of completion. In addition, phase II of the scheme was launched in January 2022 to cater to another ~20 GW of RE capacity (PIB 2022a). However, delays in the commissioning of transmission projects and the unavailability of power evacuation capacity are increasingly becoming a bottleneck (Gagal 2022; RenewableWatch 2022; CERC 2021b).

The second aspect is the integration of variable RE in the electricity grid; this has a bearing on the power system's stability and reliability (IEA and NITI Aayog 2021; CSTEP 2021). To address the issue of grid stability, auctions of RE under innovative procurement formats are increasing. These formats include wind-solar hybrids (with or without battery energy storage system (BESS)), round-the-clock (RTC), assured peak power supply, and most recently, even standalone BESS.

Figure 6: Yearly RE capacity auctioned



Source: Author's compilation based on data from SECI and state bidding agencies;
Note: the BESS is expected to supply auctioned MW capacity for 2 – 2.5 hours

In recent studies (R. Singh, Ghate, Ningthoujam, et al. 2022a; 2022b), BESS technology is being increasingly identified as a key enabler in achieving India's ambitious RE targets (Vedachalam and Atmanand 2018). However, the cost of BESS and the inaccessibility of low-cost financing have been highlighted as barriers to the large-scale adoption of BESS technology (Tomar 2021; CEEW CEF 2020).

3.4. Finance – state of play

RE, much like any other type of infrastructure, is majority debt-financed, usually to the tune of 75% in the case of India (Dutt et al. 2021). The financing challenge for debt can manifest in one of three ways. First, in certain instances, it may just not be flowing at all. This does not appear to be the case with Indian RE. To illustrate, more money was raised by Indian RE developers in the international bond markets (USD 3.6 billion) in the first six months of 2021 than in any previous full calendar year (Garg, Jain, and Sidhu 2021). Second, finance may be flowing but at an inordinately high cost. This, too, is not the case with India. In January 2022, just before a global reversal of the interest rate cycle, state-owned non-bank finance companies Power Finance Corporation (PFC) and Rural Electrification Corporation (REC) announced further reductions in borrowing rates for RE projects, to as low as 8.25% (REC 2022). For perspective, the yield on the 10-year Treasury bond at the end of January 2022 was 6.44% (CEEW CEF 2022c).

This brings us to the third manner in which the debt financing challenge sometimes manifests. Which is that it may be flowing and at a reasonable cost, but it is not flowing at a sufficiently large enough scale. This is the precise nature of the financing challenge facing Indian RE today. In January 2022, the Parliamentary Standing Committee on Energy and MNRE estimated that India would require annual investments of INR 1.5 - 2.0 lakh crore (USD 19 billion – USD 25 billion[2]) to meet the 2030 RE targets (MNRE 2022a). The report went on to estimate that against this requirement, an actual annual investment of INR 75,000 crore (USD 9 billion) was being mobilised in recent years, leaving a significant >50% financing gap.

Identifying the various ways in which debt is typically sourced by Indian RE developers provides further granular insight into the challenge. There are four distinct sources, as illustrated in Table 3 below, depending on how it is being raised and where it is being raised.

Table 3: The four engines of debt finance for Indian RE projects

	Domestic INR	International USD
Institutional debt (Banks & NBFCs)	**Dominant source:** amounts typically difficult to determine, typically clubbed into power	**Recently emerging:** initially driven by development banks, private lenders are now entering
Debt capital markets (Bonds)	**Largely untapped:** few and small issuances by private developers	**Fast growing:** 21 bond issuances totalling USD 11.2 billion (until June 31, 2021)

Source: CEEW-CEF Report "Financing India's Energy Transition Through International Bond Markets" (Garg, Jain, and Sidhu 2021)

4. Recommendations

The road to achieving India's 2030 RE targets flows through some evidently differing building blocks or considerations. The question that naturally follows is, what exactly can be done to address the challenges that lie on that road? We have listed one recommendation for each of the considerations below. In the case of the first two considerations (diversity of routes and policy effectiveness), they represent pointers for policymakers which provide high-level guidance to address the considerations. In the case of the last two

[2] USD figures, where converted to or from INR in this report, have been done so at an exchange rate of USD 1 = INR 80

considerations (grid adequacy and finance), they represent pinpointed solutions in the nature of financial interventions which can catalytically mobilise capital.

Diversity of routes

Look beyond discom-dominated RE procurement

- Utility scale RE (for discoms) in the last two full FYs was at a rate of less than 20 GW each year, which is less than half of the 40 GW requirement.
- The other traditional sources (rooftop, corporate & exchange) are not at a scale to make up the gap. In FY 22, these three combined accounted for a cumulative 7.92 GW.
- Emerging (EVs) and over-the-horizon (green hydrogen) can be crucial for India to achieve its RE targets.

Policy effectiveness

Enforce regulatory mandates & introduce or align policies

- Utility-scale RE: lax RPO enforcement has historically constrained the uptake of RE by discoms (Sidhu and Jain 2021). While the RPO formula itself has recently been revised to make it more aligned with India's RE target, achieving the same will still require close monitoring and enforcement of RPOs.
- EVs: there are two levels of policy incentives. National-level incentives are equally applicable across the country. On the other hand, only a handful of states have introduced state-level policies. Our ongoing research finds that states with EV policies are showing far superior volumes versus states with no policies. Thus, the many states that do not yet have EV policies should strongly consider introducing them.
- Green hydrogen: exports, blending where grey/black hydrogen is already being used (e.g., ammonia, fertiliser), and blending which can partially displace fossil-based fuels (e.g., CNG) are expected to be among the early use cases. Policies may be staggered to focus on accelerating the early phases over the likely later adopters.

Grid adequacy

Address BESS technology risk perception

- From the analysis of RPO trajectory till 2030, the non-hydro RE share will grow from 10.8% in FY 22 to 31.7% in FY 30; thus, BESS can become crucial for grid stability.
- There are three primary barriers that are inhibiting the scaling of BESS (CEEW and World Economic Forum 2022):
    - Lack of knowledge and familiarity with the technology.
    - Lack of business models available to scale energy storage solutions.
    - Limited financing options due to lack of project performance.
- All three barriers are posing challenges today. However, addressing the first is fundamental, as without doing so, business models and financing options will find it challenging to develop.

- Therefore, a technology de-risking fund could be a targeted solution to overcoming the first, and arguably the most fundamental, barrier (CEEW and World Economic Forum 2022).

Finance

Catalyse the opening of the domestic debt capital (bond) market

- The challenge with the financing sources that are flowing is that:
    - In the case of domestic institutions (banks & NBFCs), they face headroom constraints and would not be in a position to fund the targets by themselves (V. P. Singh, Dutt, and Sidhu 2022).
    - In the case of international debt capital markets, they have proved to be an intermittent source of capital for Indian RE developers. So, while 2021 was a record year for issuances via this route, activity has been muted in 2022, with no issuances since April.
- As such, it is imperative to focus on the other two sources, and from that perspective, catalysing the domestic bond market represents the more attractive option.
- It is estimated that a facility (see BOX 1 for details) capitalised at as little as USD 20 million would be able to catalyse GW-scale bond issuances (CEEW and World Economic Forum 2022).
- Doing so could create a valuable track record of credit performance for RE bonds, catalysing the opening up of the domestic bond market in a self-propagating manner.

BOX 1: Capitalising a credit enhancement facility: five parameters

Extent of capitalisation: Based on (a) the underlying MW portfolios of two recent domestic bond issuances in India and (b) a 16.7x multiplier as determined by a CEEW study titled "Refinancing India's Energy Transition", we estimate that a facility capable of mobilising GW scale bond issuances for RE could be capitalised for as little as USD 20 million.

Cost to user: Inversely proportional to the extent of subsidisation.

Extent of subsidisation: Dependent on (a) the capital stack that capitalises the facility and (b) the proposed additional charges for accessing the facility. If the capital stack is "all grant" with zero additional charges levied, then the extent of subsidy would be equal to (i) facility capitalisation plus (ii) opportunity cost of additional charges not levied (iii) resulting in "zero" cost to user in this instance.

Conditionality to access: Take out of INR only project debt extended by banks & NBFCs (no refinance of bonds or other securities). No top up in excess of project debt being taken out (no general corporate purpose portion to be used as equity replacement).
Source of funding for capitalisation: Multiple sources will need to be tapped, and the final capital stack may represent a blend from diverse sources such as development finance institutions, multilateral development banks, philanthropies and carbon markets.

In closing, India's power sector transition is often viewed through the narrow prism of specific considerations or building blocks, such as policy or finance, for instance. This is no surprise given that each building block merits dedicated consideration on its own. Even so, a holistic evaluation of the building blocks, including how they interact with each other can be a valuable reminder of the inherently complex nature of the challenge. Such an evaluation which balances the individual components against their interaction as a whole is critical for India to achieve its 2030 RE targets.

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