CEEW
THE COUNCIL

ADDRESSING RENEWABLE ENERGY CURTAILMENT

A composite approach

#REdialogue

WHAT IS CURTAILMENT?

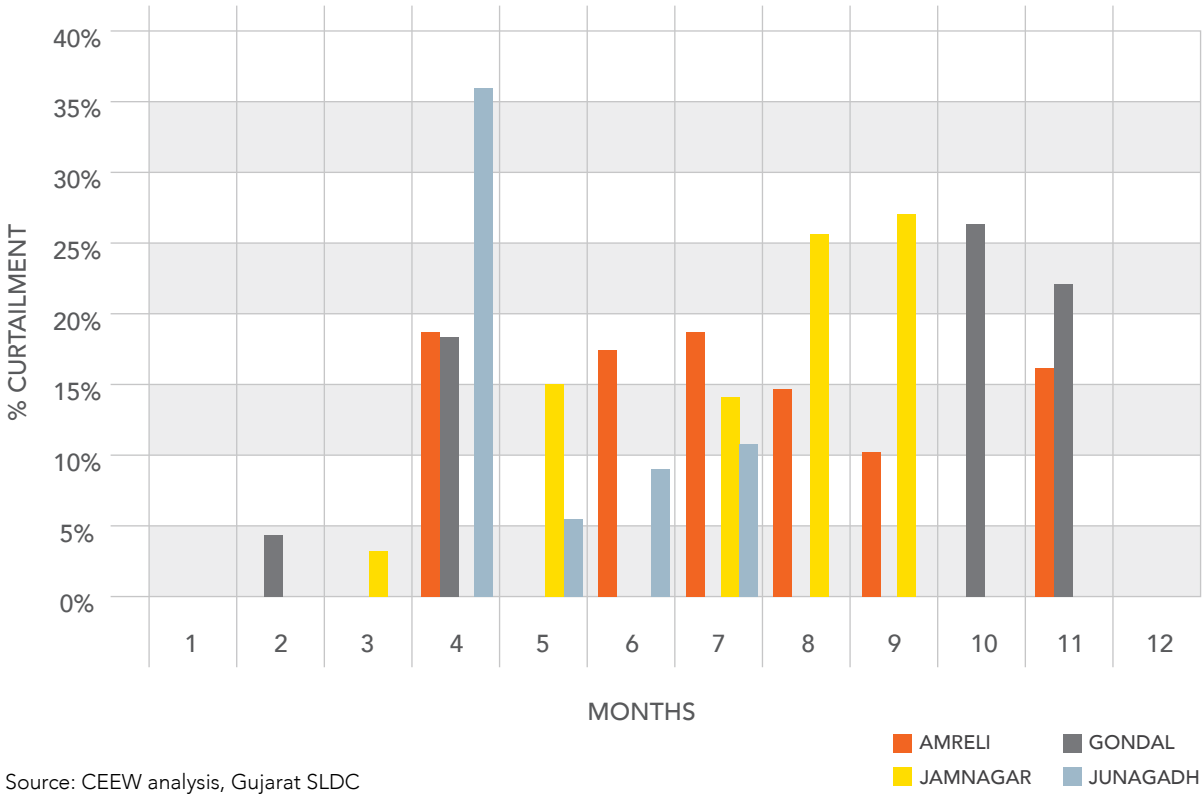
Curtailment relates to a phenomenon where the power-grid operator issues an instruction to limit the power output of specific generators. Curtailment is only permitted on grounds of maintaining grid stability and system safety, as per the Indian Electricity Code and the renewable energy power purchase agreements.

Image: Unsplash

The quantum of curtailment is not uniform across months or states, (see figure 1 below). With the current status of the power sector, curtailment is only expected to increase along with the growth in proportion of renewable energy **(RE)** in the energy mix due to technical reasons.

The quantum of curtailment is not uniform across months or states

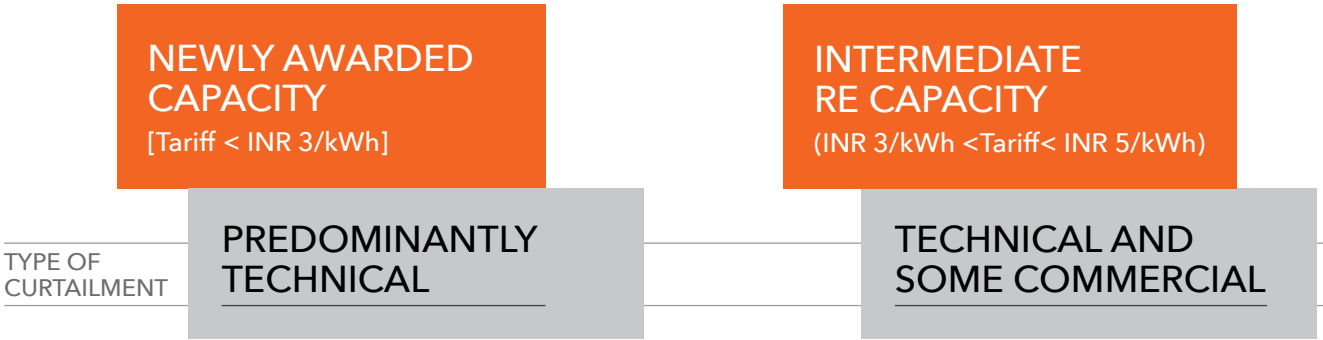
FIGURE 1: **Curtailment is a function of location and time period**



Source: CEEW analysis, Gujarat SLDC

Why does curtailment happen for RE Power?

FIGURE 2:
Nature of the Curtailment risk is changing from commercial to technical



Source: CEEW analysis

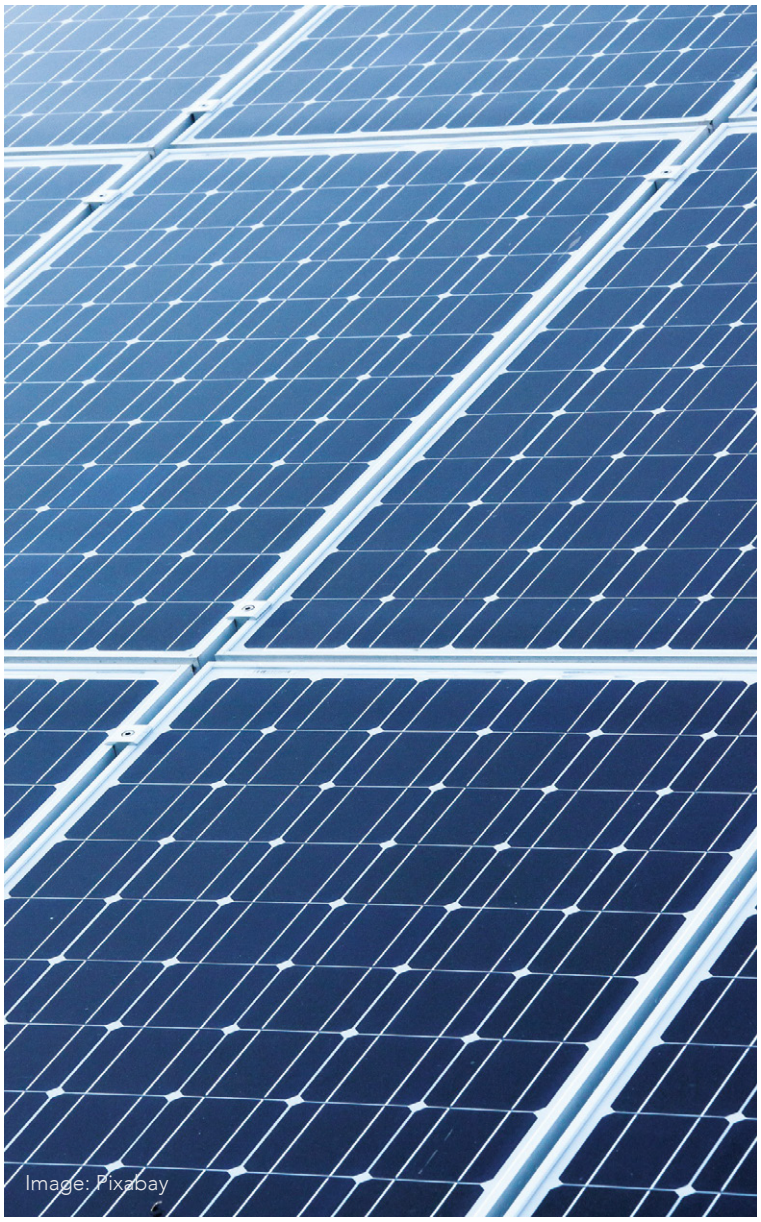


Image: Pixabay

Why is it important to mitigate curtailment risk?

BENEFITS TO DEVELOPERS

i. Lowering cost of capital
ii. Ensuring the sustainability of RE tariffs
iii. Robust reapportionment of risks in the power system

SYSTEM-WIDE BENEFITS

i. Fewer stressed assets on the balance sheet of banks
ii. Lower tariffs for consumers
iii. Lower GHG emissions
iv. Effective resource utilisation of installed RE capacity

OLD
RE CAPACITY
(Tariff > INR 5/kWh)

BOTH TECHNICAL AND COMMERCIAL

I. **COMMERCIAL CONSIDERATIONS**
Single part tariff structure and higher RE tariffs for older contracts compared to thermal power.

II. **TECHNICAL CONSIDERATIONS**
Variability of RE and absence of an adequate infrastructure to integrate higher RE into the grid. Seasonality and availability of RE resources further compound the technical curtailment risk.

THE POLITICAL ECONOMY OF CURTAILMENT

RE DEVELOPERS AND INVESTORS

Curtailment affects the attractiveness of the RE sector for RE developers and investors. Unanticipated curtailment negatively impacts returns on investment and project viability. This may translate into more stringent terms of finance for projects located in regions characterised by high curtailment risk, which in turn would hurt the competitiveness of renewable power with conventional power. Unanticipated continued curtailment could also end-up hurting the financial feasibility of some renewable energy projects, in turn causing them to default on loan repayment.

POWER DISTRIBUTION UTILITIES (DISCOMS)

Distribution companies **(DISCOMs)** are required to offtake renewable power to meet their renewable purchase obligation **(RPO)**. However, given the poor state of DISCOM finances and fixed consumer tariffs, these state entities prefer to offtake power from the lowest tariffs. Higher RE tariffs pertaining to older installed capacity and the differential tariff structure of thermal versus RE generation tends to lead to a preference for curtailment of RE generation over thermal generation for state utilities. RPOs can be met by purchasing renewable energy certificates which are available in large supply without posing the same financial burden on the utilities as some of the PPAs of the past. DISCOMs are required to ensure constant supply of stable power. However, renewable power is variable and difficult to accurately predict, schedule, and mange. To make matters more difficult, there has been industry resistance to the implementation of scheduling and dispatch regulations (that is applicable to other sources of power).

GRID PLANNERS

State Transmission Utilities **(STUs)** are expected to maintain minimum standards of performance with respect to transmission system availability. In cases of non-compliance with the minimum standards of performance, STUs are expected to compensate affected electricity buyers (DISCOMs) the transmission charges of the particular element of the system to the extent to which it has affected the supply of electricity. However, no compensation exists for RE developers in such situations.

GRID OPERATORS

State Load Dispatch Centres **(SLDCs)** control the scheduling and despatch of electricity within a state. Given that SLDCs, STUs, and state-owned DISCOMs are entities under the control of the state government, there is a fair degree of alignment between their interests. Thus, there is an incentive for SLDCs to act in the interests of state DISCOMs, backing down older RE installed capacity instead of thermal generation. SLDCs may also act in the interest of the STUs, by covering for their non-compliance with the minimum performance standards, citing grid safety issues.

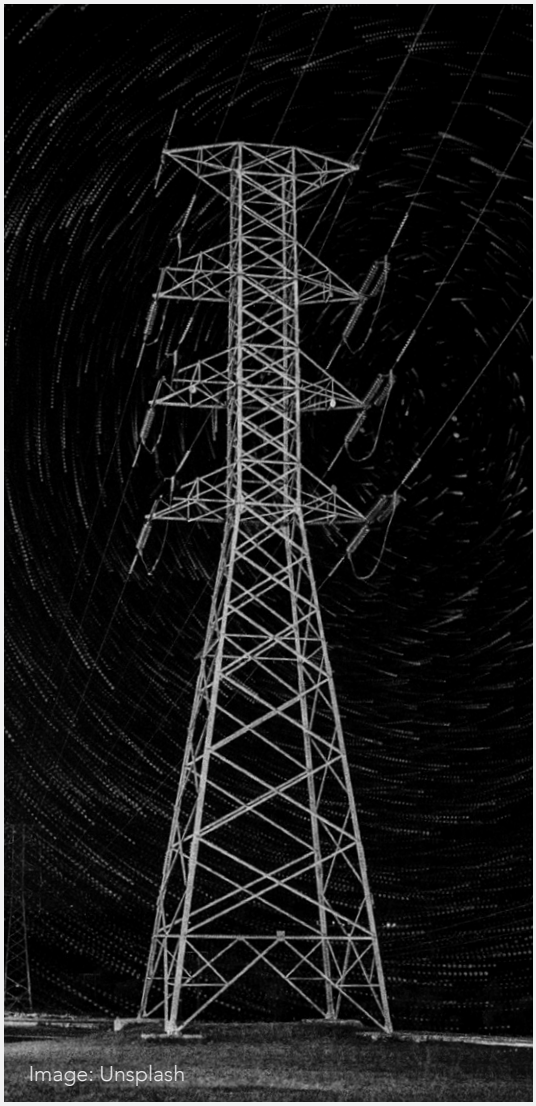


Image: Unsplash

How are the central and state governments trying to mitigate curtailment risk?

REGULATORY MEASURES

Forecasting and scheduling regulations for wind and solar generation are under consideration in a number of states with a few states having notified final regulations. Other measures include increasing balancing control area and higher deviation limits for states with high renewable energy potential.

CONTRACTUAL MEASURES

Contractual provisions in the form of minimum offtake guarantee clauses have been considered in model Power Purchase Agreements (PPAs). These clauses aim to safeguard the interest of developers and investors in the event of generation curtailment.

TECHNICAL MEASURES

A range of technical interventions are at varying stages of consideration or implementation including the strengthening of transmission capacity, flexible thermal generation and utility-scale storage. Efforts are also underway to increase the availability of real-time operational data pertaining to renewable energy sources.

What is The Council doing about curtailment?

Curtailment is likely to have a significant impact on the pace and feasibility of RE deployment going forward. To systemically address the technical risks posed by the growing proportion of RE in the energy mix, significant grid upgradation efforts are necessary. However, these are both investment and time sensitive. While several of these technological improvements are either underway or planned, they require a five to six year horizon.

The Council has adopted a composite approach, with a focus on identifying immediate stop-gap solutions to address the impacts of curtailment. A suite of financial and non-financial options have been developed that could be implemented individually, or together. They include:

i. Restructuring RE power purchase agreements **(PPAs)** to balance out the risks pertaining to curtailment amongst the parties responsible for its occurrence.
ii. Grid Integration Guarantee **(GIG)**, which is a short-term intervention that could underwrite the risk of curtailment.

Both these solutions have been described in detail in the following sections.

GRID INTEGRATION GUARANTEE

The Grid Integration Guarantee **(GIG)** is an innovative and market-transformative instrument to mitigate the curtailment risk.

The GIG is built upon the intersection of two major disciplines and technologies- big data techniques and actuarial science. GIG aims to support deep de-risking of renewable energy assets making them suitable for the risk-return requirements of institutional investors. Its offering could help in bringing part of the half trillion dollars required [1] in the mitigation finance in developing countries, at affordable terms.

[1] Fankhauser, Samuel, Sahni, Aditi, Savvas, Annie and Ward, John (2016) Where are the gaps in climate finance? Climate and Development, 8 (3). pp. 203-206. ISSN 1756-5529

Has something similar to GIG been tried/ offered before?

No.

Why The Council thinks it's possible?

Power systems across the world use sophisticated dispatch and communication systems. Millions of terabytes of data are generated in power systems operations every hour. We believe that this data can be leveraged to model and calculate premiums and offer an instrument that can accurately price and successfully underwrite the risk of backdown.

FUNDAMENTAL PRINCIPLE BEHIND GIG

Curtailment risk needs to be moved away from developers to grid operators and grid planners such as TRANSCOs and SLDCs since they are in the best position to manage it.

Which gaps does the GIG address?

i

PPAs in current structure do not address the curtailment risk. Barring some very recent PPAs in India, most of the Indian PPAs do not address curtailment risk. Even the newer PPAs do not address the tail end curtailment risk. The GIG aims to insure against tail-end curtailment risk.

ii

Curtailment is a very local phenomenon. The incidence rates of curtailment vary even among smaller geographies. Universal interventions such as executive diktats and regulatory interventions, for a local issue such as curtailment, do not offer much comfort to investors. The GIG intends to offer protection against curtailment at the substation level.

iii

The curtailment risk paradigm is changing both in quantum and nature in India. The newer capacities while facing relatively lower commercial curtailment risk compared to older RE capacities, would face very high technical curtailment risk going forward. The GIG covers the risk on receivables from all forms of curtailment.

How does it function?

GOVERNANCE

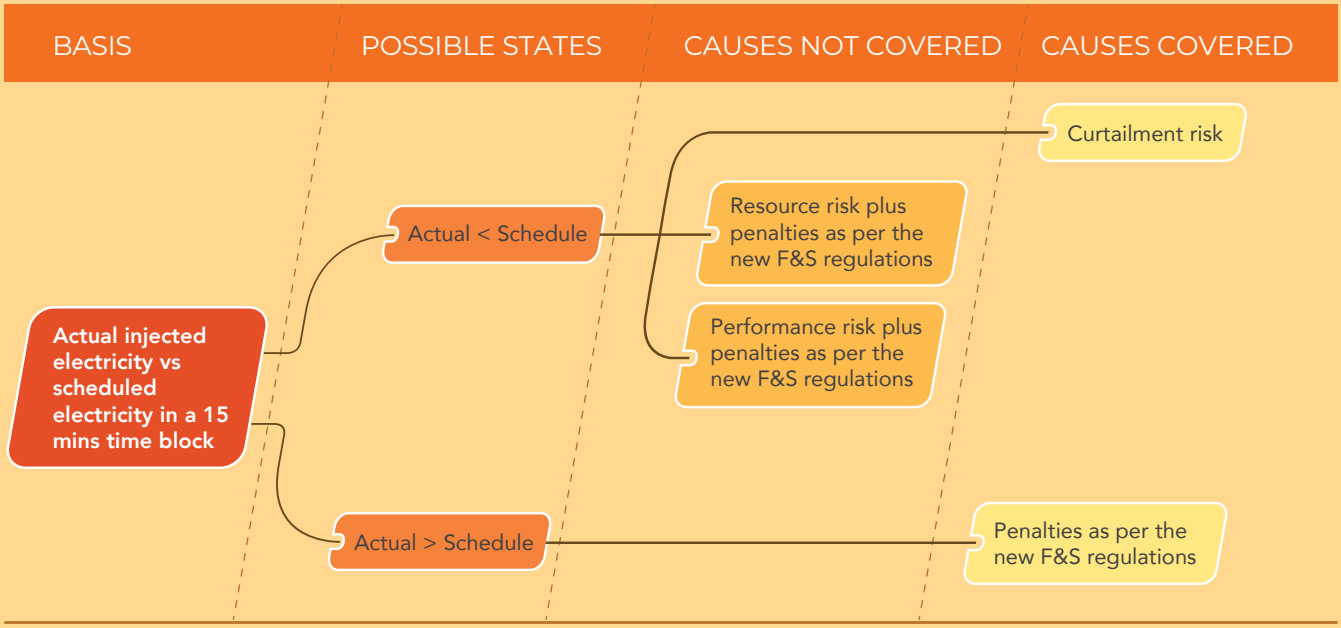
The governance of this instrument would depend on the offering entity. It could be decided either by the state governments (in case of state grids) or the federal government (in case of ISTS network), if the instrument is offered by the government, partly leveraging public money and rating. The government could choose among a spectrum of options ranging from an insurance-based model on one side to a trust-based model on the other. As the size of an insurance market, where government pays full or partial premiums for the insured, increases [2], governments tend to go for a trust-based model to optimise the costs and avoid the operational margins. In the case of GIG, governments are likely to opt for a hybrid version of a trust- and insurance-based model.

[2] Health Insurance market is one such insurance market

COVERAGE

The GIG only measures curtailment against the scheduled energy and does not cover other risks such as resource risk, performance risk and quality risk. (see Figure 3).

FIGURE 3:
GIG only covers the curtailment risk and penalties associated with curtailed units



Source: CEEW analysis

CAPITALISATION

A well-capitalised insurance entity is expected to elicit more insurable interest due to its higher rating. Designed as a market reflective guarantee, the guarantor would be capitalised through:

i. Premiums from developers
ii. Domestic public money such as Indian federal government and state governments on the behalf of national and state grid planners and grid operators
iii. International public money sources such as Green Climate Fund, development aid money, etc.

PREMIUMS

Higher premium rates reflect higher risk of curtailment. Premium rates for the use case of the GIG are calculated for Gujarat as grid dispatch data was only available for the state of Gujarat.[3] The premiums for solar technology are not calculated since currently there is limited curtailment for solar power. Premium rates for wind sector are divided into four circles- Amreli, Anjar, Junagadh, and others (see Table 1). The others category includes all circles except the three circles for which separate premium rates are listed. An important point to note is that these values are only indicative in nature and should not be taken as a substitute for the technical pricing required for offering a marketable instrument.

The two scenarios- optimistic and pessimistic are the extreme ends of the range of the probabilities of curtailment that different techniques calculated. Due to the challenge posed by data paucity, the ranges are fairly wide. With improved data, the accuracy of the probability calculation will improve significantly.

[3] Various statistical and actuarial techniques such as autoregressive integrated moving average (ARIMA), exponential smoothing; simple averages, etc. have been used to calculate the premiums.

TABLE 1: **Range of premium rates for different circles for wind generators**

COVERAGE	PREMIUM RATES	CIRCLE			
		AMRELI	ANJAR	JUNAGADH	OTHERS
100%	Optimistic	12%	6%	22%	2%
	Pessimistic	18%	20%	29%	3%
90%	Optimistic	11%	5%	20%	2%
	Pessimistic	16%	18%	26%	3%
80%	Optimistic	10%	5%	18%	1%
	Pessimistic	14%	16%	23%	2%
70%	Optimistic	9%	4%	15%	1%
	Pessimistic	13%	14%	21%	2%
60%	Optimistic	7%	4%	13%	1%
	Pessimistic	11%	12%	18%	2%
50%	Optimistic	6%	3%	11%	1%
	Pessimistic	9%	10%	15%	1%

Source: CEEW analysis

SETTLEMENT OF CLAIMS

The pay-out frequency of the GIG is linked to the interest payment cycles (quarterly), to smoothen and protect the cash flows of RE investors and developers. This instrument takes care of a situation where higher curtailment in the initial months of a year resulting into a pay-out from the insuring facility, is followed by excess electricity injection in the later months. The GIG is structured to have a quarterly reconciliation to manage the working capital issues. (See Table 2 for a sample calculation).

TABLE 2: **A sample case showing calculation of pay-outs and quarterly reconciliation**

MONTH*	SCHEDULED GENERATION (kWh)	ACTUAL GENERATION (kWh)	CURTAILED GENERATION (kWh)	PENALTIES (INR 1.5/kWh) (if any)	TARIFF (INR/ kWh)	POTENTIAL compensation (curtailed units)
Month 4	80	60	20	0**	3	60 at the end of Month 6
Month 9	80	110	-30	45	3	0
End of year	160	170	-10			Developer injected 10 extra units but will still get INR 60 as compensation for the entire year, but will have to pay the penalty for the deviation from the schedule in month 9

Source: CEEW analysis

* No curtailment or additional injection in other months
** No penalties in the case of curtailment

LOWER PREMIUM ON A PORTFOLIO DUE TO DIVERSIFICATION

States where curtailment could be high in certain months could be mutualised by lower curtailment in other states. A RE developer/investor with projects in multiple states/ countries could enjoy lower premiums on its portfolio compared to a developer with projects only in handful of states. But the instrument offers de-risking for small developers with projects concentrated in one circle/state, albeit at a higher price (see Table 3).

TABLE 3: **De-risking a RE portfolio is cheaper than de-risking standalone projects in risky locations**

NATURE OF PROJECT/ PORTFOLIO	AMRELI (in MW)	ANJAR (in MW)	JUNAGADH (in MW)	OTHERS (in MW)	PREMIUM RATES*
Highly Diversified portfolio	250	250	250	250	10.52%
Standalone project in a highly risky location	0	0	1000	0	22%
Standalone project in a lesser risky location	0	1000	0	0	6%
Intermediate level of diversity in the portfolio	0	500	500	0	14%

Source: CEEW analysis

* Optimistic scenario

Additional benefits of GIG

i. **Informing the pace of sustainable RE capacity addition** - The risk premiums on the GIG would further inform the policymakers about the feasible pace of RE capacity additions. A higher risk premium will signal that the transmission and dispatch capability is relatively weak in the location for which insurance is sought.

ii. **Calculating a high frequency, local, and market-based cost of grid integration** - Higher premiums will signal to the government about the increasing congestion/back down in certain parts of the grid. Since the risk premiums are local, market-based and are dynamically calculated, this estimate of grid integration cost would be better than any top-down or bottom-up estimation of the grid integration cost presently available.

Could GIG be deployed in the market?

While GIG needs to be developed further before it becomes available for offer in the market, this report should be used to assess the idea of the GIG and the utility of use case and framework of the guarantee in further de-risking RE investors and developers, not just in India but across the globe.

Next steps

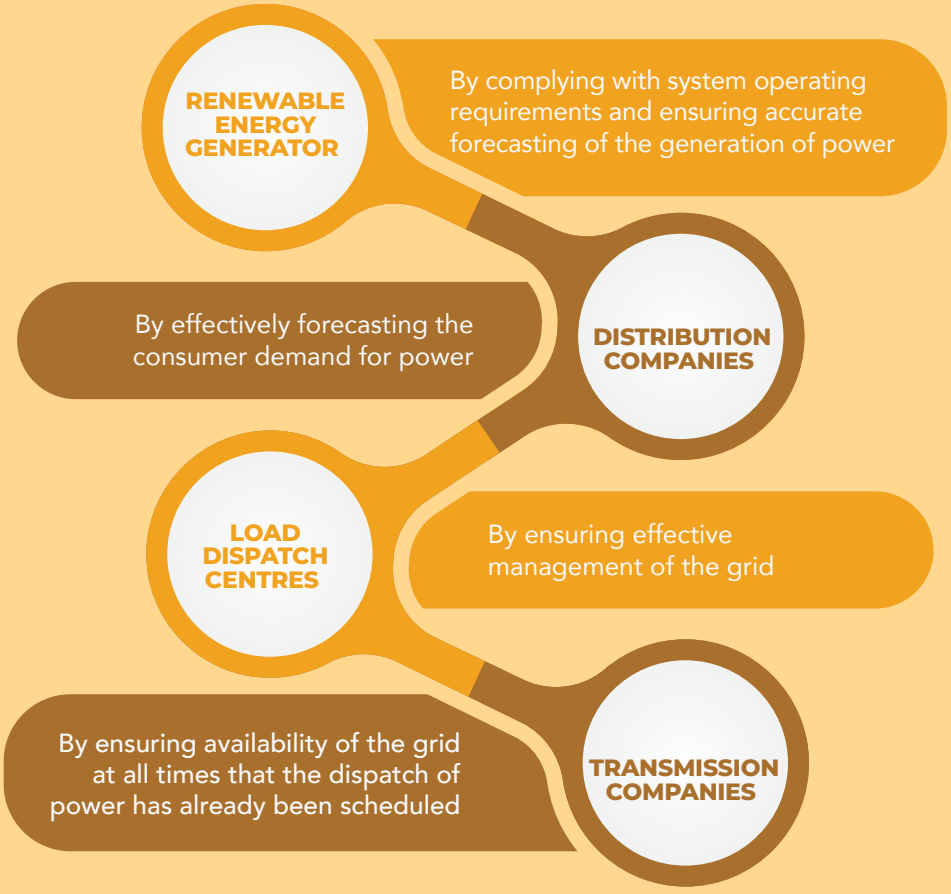
i. Gauging interest from RE developers and investors
ii. Stakeholders consultation with important stakeholders such as TRANSCOs/SLDCs
iii. Model the future grid instead of forecasting based on old data
iv. Working with other states so that they make their grid dispatch data available
v. To offer a comprehensive product including resource and performance risk

Image: Unsplash

RETHINKING PPAs TO MITIGATE CURTAILMENT RISK

How will contracts help alleviate curtailment risk?

Contracts can be used as risk mitigation instruments by allocating risks to the party that is best able to control and manage it (both in terms of the likely occurrence of the risk and its effects). In case of failure to manage the risk as anticipated at the time that the agreement is signed, compensation is due to the affected party. This provides more certainty to the contracting parties.



Who can control curtailment risk?

Despite four parties being responsible for the risk of curtailment, the PPA, which dictates the terms of the power supply and offtake from the RE project, is entered into between the RE generator and the DISCOMs.

There is an emerging need to hold the load dispatch centre and the transmission companies accountable for occurrence of curtailment in case of failure to perform their obligations.

How have contractual structures evolved so far to specifically deal with curtailment risk?

In 2017, the guidelines for tariff-based competitive bidding for both solar and wind projects was introduced by the Ministry of Power. The guidelines contained specific provisions for 50% compensation in case of grid unavailability and grid curtailment beyond a specified quantum on unavailability/ curtailment per year. However, this excludes situations where curtailment is on account of grid safety and security concerns.

These newer provisions fail to adequately address the risk since:

i. Compensation is at 50%, which will still lead to a substantial risk and an affiliated increase in tariff.
ii. Technical curtailment on account of grid safety issues is still at large owing to the exemption.

Further, in the REWA project PPA, compensation at the tariff price was promised in case the renewable energy generators face curtailment or grid unavailability issues beyond a period of 175 hours a year, with no exemptions for grid security concerns. However, the guaranteed quantum of power for which this provision will apply, amounts to less than 70%[4] of the capacity utilisation factor of the project. Thus, there is a tradeoff.

[4] These numbers are as per the REWA draft PPA available in the public domain as of November 2016 and may not represent the final figures that were agreed upon between the parties.

Is there a more robust way of structuring contracts to effectively deal with the risk of curtailment?

i. **Establishing a guaranteed quantum of power generation at the outset is crucial.** An agreeable quantum of power which will be the minimum quantity that the renewable energy generator is guaranteeing to supply, which is equal to the maximum quantum that the offtaker is guaranteeing to offtake, must be decided upon.

ii. **Comprehensive definition** of what would constitute curtailment risk is imperative, together with an indication in the PPA regarding the quantum of estimated occurrence of this risk (which comprehensively includes all forms of curtailment), to make it more predictable.

iii. **Full compensation** (to the extent of the tariff amount) needs to be provided beyond the limit that will be fixed in the PPA for any kind of curtailment (in terms of number of hours per year).

iv. **Hold all concerned parties accountable:**
   a. RE generators must ensure supply of power within the prescribed frequency band
   b. Offtaker must be in complete control over scheduling demand
   c. The concerned load dispatch centre must ensure that subject to the generator and offtaker complying with their commitments, the grid can accommodate all renewable power that is scheduled to be generated (with the exception for estimated occurrence of curtailment that has been defined in the PPA, as cushion).
   d. The transmission company must ensure that the grid remains available beyond the agreed levels of unavailability that is documented in the PPA.

Penalty provisions, at the rate of the agreed tariff, in case of failure to comply will be included in the PPA.

What additional steps need to be taken to implement this contractual structure?

i. Ensuring transparency in operations by increasing the availability of real-time operational data pertaining to RE sources

ii. De-linking the functions of the SLDC, transmission utility, and DISCOMs from each other to ensure efficient performance

iii. Implementation of better forecasting technology to raise the quantum of minimum guaranteed supply

iv. Robust grid infrastructure to accommodate variable quantum of renewable energy

Image: Unsplash

Meet the Renewables team @ The Council

The Renewables team supports India's – and the world's – clean energy transition. It does so through timely, research-based interventions based on extensive policy, regulatory, and market analyses. The team also assesses, through surveys, India's renewable energy jobs potential and skills requirement, the risks facing renewable energy investments, and designs strategic financial mechanisms to address the identified risks.

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