Issues related to renewable energy grid integration with a focus on forecasting, scheduling and deviation settlement regulations for wind and solar power

Summary report of roundtable discussion

21st August, 2017, Mumbai, 9:45 – 3:30 pm
Venue: Committee Room (31st floor), World Trade Centre, Centre 1 building, Cuffe Parade

The Government of India has announced a target of 175 GW (100 GW solar, 60 GW wind) of renewable power in the country by 2022. Considering this target, the penetration of renewables may reach as high as 33% in terms of capacity and 21% in terms of annual generation. Almost 80% of this renewable energy deployment is expected to be in eight states (Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Andhra Pradesh, Telangana, Karnataka and Tamil Nadu) mainly in the southern and western regions.

Wind and solar generators differ from conventional generators in two important ways, namely the variable nature of generation (dependent on the weather) and the single part nature of the tariff. The near zero marginal cost of wind and solar generation allows them to be ranked higher up in the merit order (with or without must-run status) in day ahead despatch, potentially displacing other generators. The intermittent nature of wind and solar generation can also cause challenges in the grid operation like higher ramping requirements to meet net load (actual load – must run renewable generation), uncertainty in scheduling and despatch, decrease in capacity utilization factors of conventional power plants and transmission lines, suboptimal operation of conventional power plants due to decrease in their minimum generation levels, increased cycling resulting in higher wear and tear, increase in station heat rate and auxiliary consumption etc. Operating the grid efficiently, economically and securely with high penetration of wind and solar generation, especially with concentrated deployment in few states can be additionally challenging. A recent national level production cost study done jointly by NREL and LBNL in association with POSOCO concludes that the power system can maintain balance and manage the added variability of wind and solar without the need for new, fast-ramping infrastructure (such as natural gas turbines), provided that the system is able to tap the flexibility of the coal fleet and take advantage of national and regional coordination of scheduling and dispatch to ease renewable energy grid integration.

One of the important steps that the regulatory set-up has been working on is the introduction of forecasting, scheduling and deviation settlement mechanism for wind and solar generators. While such regulations have been firmed up by CERC for regional entities connected to the inter-state grid, they are still lacking for generators connected to the state grid, in spite of draft regulations from 7 states[1] being in place for a long time. A report analysing such national and state level regulations was published by Prayas (Energy Group) in September, 2016 and can be accessed here. Karnataka is the only state to have finalized and begun implementing their regulations while draft regulations for Maharashtra are expected very soon. Andhra Pradesh has recently finalised their regulations. Hence it is crucial to comprehensively understand the various techno-economic issues and implications for various stakeholders arising out of implementing

[1] States include Tamil Nadu, Odisha, Madhya Pradesh, Jharkhand, Chattisgarh, Rajasthan and Gujarat.

such regulations in states. Another recent study looking at the regulatory dimensions to RE forecasting, scheduling and balancing in India is available here.

Enacting regulations for forecasting, scheduling and deviation settlement for renewables is only one of the important steps needed in the overall sectoral effort towards reliable and cost-effective grid integration. As the share of variable renewable energy increases in the years to come, it will be crucial to understand its implications on various actors in the system and the need for added flexibility (both on the generation and demand side) in the system. There are several ways to generate flexibility, like increasing ramping rates and reducing the technical minimum generation levels of conventional thermal generators, adding storage (pumped hydro and electric batteries), demand side management, market mechanisms like ancillary services etc. More importantly it would be critical to understand the cost of this increased flexibility and principles for fair allocation of this cost amongst various concerned stakeholders. Such issues will also need to be reflected in various contracts, agreements and bidding guidelines. A variety of policy and regulatory changes are also under discussion in this context. Some of these are: (a) compensation for wind and solar generators being backed down, (b) two part tariff for wind and solar, gradual removal of must run status and energy banking (c) compensating conventional generators for flexibility, (d) combining balancing capacity like storage/gas generators with wind/solar plants etc. Finally electric storage costs have been coming down drastically and can have a very high impact on grid planning and operation, an issue which has not received much attention. Understanding the implications of MW scale grid electric storage would be crucial to improve the sector's readiness in adopting such new technologies.

In this context, Prayas (Energy Group) organised a roundtable discussion to deliberate on the various specific challenges around forecasting, scheduling and deviation settlement regulations for renewables and broader RE grid integration aspects. The discussion was carried out under Chatham House rules to enable frank and open discussions. The objective was to understand the different perspectives of various stakeholders (ERCs, Generators, DISCOMs, LDCs, etc.). Our hope was that these deliberations would constructively inform policy and regulatory officials as they work on the important task of framing rules around renewable energy grid integration. The roundtable was attended by 36 people representing a strong diversity of stakeholders including SERCs, DISCOMs, SLDCs, Wind/Solar developers, Consulting, Thermal Generators, Transmission Utilities, Academia, Power Exchanges, Consumer representatives and Forecasting and Scheduling service providers. The detailed agenda of the roundtable is given in Annexure 1.

Summary of the discussion during the first session

The session began with Ashwin Gambhir welcoming all attendees on behalf of Prayas (Energy Group) and setting the context for the roundtable deliberations. This was followed by a detailed presentation by **Ajit Pandit from Idam Infra Advisory Pvt Ltd.** on regulatory issues and challenges in wind & solar power forecasting, scheduling (F&S) and DSM regulations. He began with outlining the history of the regulatory process with regard to F&S framework and gave a comprehensive state-wise comparison of the various attributes in the various state (draft and final) F&S regulations. Some of the comments and suggestions on operational issues received from stakeholders on state F&S regulations include a. Need for more clarity on qualifying criteria and governance structure of Qualified Coordinating Agency (QCA), b. Metering and data collection should be the responsibility of STU and data telemetry should be done at the pooling sub-station (S/S) level instead of turbine/inverter level and c. Provisions for inter-state sale of RE power need to be in line with F&S regulations. Finally, he detailed out the various challenges in implementing F&S regulations and highlighted the thinking on these issues which was done as part of the FoR technical committee in this regard. These include:

a. Regulatory oversight of QCA in appropriate regulations; technical & financial criteria of QCA and its governance mechanism. The suggestion was to limit one QCA to one pooling S/S. The QCA should be registered with the SERC and its role on the commercial side should be limited to the settlement of deviation settlement charges.

b. Need for a mechanism to operationalise virtual pool and identify entity responsible for it. The suggestion was that SLDC shall be responsible for maintaining account of virtual pool for RE deviations at state level but there needs to be a decision on whether solar deviation and wind deviations are to be accounted for separately for the purpose of 'virtual pool', particularly, where different bands & deviation charges are applicable.

c. Need of principles for de-pooling of deviation charges between RE generators at the pooling S/S.

d. Provision to cover the funding deficit of the state imbalance pool. The suggestion was to design state level imbalance pool with 'non-zero sum' features. SERCs can address this requirement while formulating DSM regulations at state level. One way for the SERCs to consider creating a state level funding support mechanism to manage deficit, is through a levy of a system benefit charge (Rs/MWh) on all Transmission System Users (TSUs).

e. Need for creating standardised metering points in all states. The suggestion was that all the parameters, namely, Scheduled Generation, Actual Injection, Deviations, and Deviation Charges should be monitored and accounted for within state imbalance pool with reference to interconnection point at pooling substation. Also it is critical to establish communication infrastructure and online real time data/information sharing facility to share requisite data/information with SLDC.

f. Setting rules for deviation settlement for RE generators connected to STU with inter-state transactions is challenging especially if the pooling S/S has both intra-state and inter-state

generators. It was suggested that all inter-state generators at a pooling S/S may be connected through separate feeders and their deviations be separately accounted for. The QCA would separately settle deviation charges with RE generators for inter-state and intra-state transactions.

He concluded by noting that addressing implementation aspects of F&S framework is crucial for operationalising F&S regulations for variable RE. For further details, please see the **presentation slides here.**

Important issues discussed and comments made during the discussion

a. **RE project visibility to LDC and importance of data:** The importance of the visibility of RE generator at SLDC is paramount. Some states presently do not have any penal clause or mandatory requirement which permits start of commercial operation only when there is visibility of the project in the SCADA system. This should be strictly adhered to for new projects from now on and should also be extended to existing projects with some time period like 6-12 months. A clear agreement among all stakeholders on the issue of data telemetry is needed, if action on this front is to happen quickly. Establishing data telemetry is a big challenge, especially considering the connectivity issue. A strong comprehensive plan and effort is underway in Maharashtra to have real time visibility of all RE pooling sub-stations (~60) with the SLDC.

   One suggestion was that while the responsibility of data from the pooling S/S to the SLDC will lie with the STU, the responsibility of data from the wind turbine/solar plant and the pooling S/S will lie with the developer.

   RE data related to schedules and generation should be hosted on a web-portal like it is done in Tamil Nadu and Gujarat. This is very helpful for data analysis for the QCA in improving forecast accuracy, especially since this process takes time.

   Presently there is not much visibility for the QCA with regard to grid shut-down times and hence they face a problem of near 100% deviation in the schedules in two time slots, when the grid is taken down and when it come up live. Some dispensation in this regard would be needed from the SERCs.

b. **Deviation error definition:** Computation of the absolute error for renewable energy deviation is presently based on 'Available Capacity'. Some of the stakeholders strongly felt that it should be based on scheduled generation in a manner similar to conventional generators, even if this requires loosening the allowable error band for RE generators.

c. **Imbalance in state pool:** RE generators connected to the STU but having inter-state transactions of power should fully compensate for any deviation/imbalance created in the state pool. This should be done quickly since the DISCOM consumers have to eventually bear such costs.

d. **Possible non-cooperation from RE generators:** One of the challenges highlighted was the issue of non-cooperation of some generators connected to the pooling sub-station due to which the QCA's work is hampered. Is there any regulatory provision to address this?

The possibility of a commercial dispute between QCA and generators is not such a big issue, especially since the first state to implement regulations, i.e. Karnataka has provided for a large bank guarantee which reduces risks for the QCA.

e. **Improving forecasting accuracy through aggregation:** While greater aggregation of pooling substations may help in forecasting accuracy, it was suggested that scheduling should be done at the level of pooling sub-station for commercial purposes. Forecasting accuracy is much better if capacity is aggregated and Renewable Energy Management Centre (REMC) is a very useful approach for RE grid integration.

f. **Intra-state schedule based accounting system:** There was some discussion on the possibility of leap-frogging some of the existing implementation issues by moving to an intra-state schedule based accounting system, which is in the offing. This may need some form of two-part RE tariff but will have the benefit of seamlessly integrating with the larger inter-state energy accounting system.

g. **System Benefit Charge:** Something akin to a system benefit charge is under active policy consideration. This would cater to the commercial implications on account of the imbalance created by wind/solar generators in the system below the allowable error, say 15%. This would cover three components: (a) balancing costs, (b) cost of additional reserves, and (c) costs on account of backing down of cheaper thermal power. This is similar to an existing framework in Germany. Such a charge would be levied on all consumers of all states and not just the RE rich states since the cost of such integration should be borne by the whole country in line with the tariff policy recommendation of having uniform RPOs. A challenging but necessary element of this framework would be to separate out of the contribution of load variability and RE variability.

   Another stakeholder noted that there were two views on how to handle the commercial implications on account of the imbalance created in the system below the allowable error. One view is to socialize this cost as a system cost, given the national vision to promote RE. Another view is to re-assign this cost back to the RE generators.

h. Importance of making a beginning: It is important to make a start with the F&S regulations rather than waiting for the perfectly drafted regulations. Also it is important to keep such regulations simple to implement. Finally, the investor has to bear some element of risk or else it will be hard to get their buy-in in the process.

Summary of the discussion during the second session

The second session began with **Ashwin Gambhir, Prayas (Energy Group)** presenting on emerging issues relating to RE grid integration beyond F&S regulations. He began by highlighting the near inevitability of rapid increase in the share of RE given the record low prices. He also noted the near ~ 7.5x increase needed in the speed of RE capacity deployment (2017-22 compared to 2002-17) and associated sectoral complexity and the need for appropriate policy-regulatory responses. He further noted the need to understand the broader implications and their institutional responsibility/additional costs arising out the inherent nature of RE generation, mainly its seasonality, its diurnal variation and existing limits to forecasting accuracy. Some of the important implications are noted below.

a. **Wind and solar Generators:** Stress on quickly implementing the new technical requirements for wind/solar generators (Low Voltage Ride Through, i.e., LVRT, reactive power support, regulation of active power etc.) to support grid operation. These are already mandated by CEA. The possibility of RE generation curtailment rises as share of RE increases, especially considering the surplus situation in some states. It is important to evolve compensation frameworks for such curtailment, especially since RE has single part tariffs unlike coal. MRNE and MoP have both proposed some frameworks on this issue.

b. **Coal Generators:** Need for increased flexible coal operation due to more cycling (lower technical minimum operation, startups, shut down, ramping etc.) and possible need for retrofitting for some plants which could result in higher fixed costs. Marginal increase in heat rates and auxiliary energy consumption leading to increased fuel costs in case of significant part load operation. Implications for Plant Load Factor (PLFs) for coal plants will differ significantly depending on position in the merit order. Finally is there is a need to consider retirement for some units/plants with very low PLFs?

c. **Regulators and policy makers:** They will need to grapple with the future of must run status and a possible two part tariff for wind and solar. They will have to explore avenues for better national and regional coordination of scheduling and dispatch, considering the various coordination processes already underway. They will also have to develop frameworks for compensating thermal generators for flexibility. Another new element for their consideration is the future of the solar/non-solar RPO categories considering the potential differing impact of wind/solar projects towards grid integration strategies.

d. **DISCOMS:** They will have to start making use of tools such as production cost models for better capacity expansion planning, esp. with rising RPO and surplus capacity. They will have to consider the possibility of increased fixed costs for inflexible plants if retrofitted and increased variable cost due to higher heat rates from cycling. They may have to evolve a framework for valuing renewable energy beyond mere generation price to include system value of a particular project (for ex: distance from transmission lines, contribution to peak demand/capacity value, need for reserves etc.)

e. He highlighted the potential disruptive implications of rapidly declining electric battery costs and its immense possibilities for easing RE grid integration challenges, though they may be some years down the line.

Finally, he stressed the need for a lot of pro-active and innovative changes in policy-regulation and continued deliberations, greater coordination between GoI and states and among sector stakeholders to overcome emerging challenges of grid integration. For further details, please see the presentation **here.**

Important issues discussed and comments made during the discussion

a. **Must-run status for renewables:** MPERC has amended their regulations which suggest that RE will now be subject to 'scheduling' and 'merit order dispatch principles'. It is not clear whether this is akin to removing their must-run status. Must-run status for RE should definitely continue or else the country will lose out on near zero marginal cost power and underutilise existing RE plants.

b. **Technical minimum of thermal power plants:** There is a strong need to reduce the technical minimum operation norm of thermal power plants to 55% of rated capacity in line with the CERC regulations. This will help states to minimise backing down of cheap thermal plants and minimise reducing the share of cheap ISGS power. There was a sense that 55% technical minimum is only possible for large units and may not be possible for 210 MW sets or older plants. There is also a need for onsite testing on technical minimum capability.

   One could also think of not having just one single benchmark value for technical minimum for all plants in the state. These could vary depending on age and testing. Broadly it would not be good to back down supercritical plants which are more efficient.

   Thermal fatigue on the plants increases due to ramping. There have been occasions when operation at technical minimum is needed only for 15 minutes. Such operation reduces life and increases costs. This should be adequately compensated for by the SERCs, especially in the case of part load operation.

   DISCOMs noted that paying fixed costs of thermal plants coupled with RE tariffs is increasing the cost of supply for their consumers.

   Another suggestion was to consider a new framework for merit order dispatch of having flexibility as part of the entire fleet and not as per individual units.

c. **Low PLFs of thermal plants:** On the issue of reducing PLFs, there was a comparison with USA which also has low PLFs for its coal fleet. It was noted that as a society we will have to bear some level of fixed costs to ensure a reliable round the year grid supply.

   It was pointed out that low PLFs should not automatically translate to plant retirement, given other consideration of costs or efficiency. Another view was that while PLFs may be going down, given the increasing demand, absolute contribution of coal in 2022 is still increasing unlike in

Western countries. There was also mention that generation activity is now delicensed and that a lot of IPPs came into the market from 2008 looking at the high market prices. They also need to assume some responsibility of low PLFs.

d. **Approaches to integrating renewables:** Some of the possible solutions suggested to overcome the limitations of RE (high wind generation during low demand; solar availability only for few hours, variable nature etc.) include solar and wind hybrids, load following generation (like supplying power to agriculture only in day-time during solar generation), pumped hydro, adequate reserves etc. The importance of pumped hydro, increasing the RE generation forecasting accuracy and fast ramping gas plants (>10%) was noted by many. However, improved forecast accuracy does not solve the ramping requirement and constraints thereof.

   There is a need to operationalise the existing pumped hydro plants and they should be incentivised for peak supply/flexible operation. It is also important to explore non-battery solutions to grid integration such as demand response and Time of Day (ToD) restructuring to make demand more flexible.

e. **Grid services from RE plants:** Most existing wind plants do not have LVRT capability which is the need of the hour. In addition, injection of reactive power from these plants creates a situation of high local voltage. Reactive power compensation equipment should be mandated as part of the capital costs of wind/solar power plants rather than just collecting reactive power penalties. While studies have confirmed the technical possibility of balancing active power with 175 GW in 2022, there are open questions over the aspect of reactive power, especially if thermal generation goes down. There is an urgent need to have state specific reactive power compensation studies along with pricing frameworks.

f. **Sharing resources across states:** There was a suggestion to enable a regulatory framework to allow better sharing of generation resources across states. Presently such transactions have to be done through STOA with applicable transmission charges. There is a need for inter-state banking framework within the limits of system security. Regional cooperation is needed to minimise area control error due to RE.

g. **Electric batteries:** A recent study noted the possible use of batteries in hybrid wind-solar plants. It could have applications in RE firming, peak shifting and reducing DSM penalties (which was found to be the most cost-effective application). It also showed that load forecasting errors contribute significantly more than RE variability to imbalance. Hence it is very important to stress on improving load forecasting by DISCOMs for better system operation. Another stakeholder reiterated the importance of batteries for grid integration, especially for ramp down/up applications in the morning and evening in a solar heavy system like India has proposed. It is important to consider the cost-benefit analyses while going ahead with deployment of electric batteries. For example, what is the value provided by electric batteries in avoiding or delaying large investments in transmission?

h. **Transmission:** It is important to understand the contribution of RE to peak demand and the cost implication of building significant new transmission capacity with very low CUFs. There is a need to debate the transmission implications of the 175 GW, especially since no study seems to be done to understand the share of this capacity within the InSTS and the ISTS. This is important to consider given the waiving of ISTS charges for wind and solar plants for a given time period and the construction of the Green Energy Corridor.

i. **Balancing and its costs:** Some recent analyses show that even RE rich states like Tamil Nadu can handle variability within the state with existing flexibility of thermal generators. But enabling regulations on this account is needed. Studies are beginning to show that low cost RE including its balancing cost is cheaper than coal.

j. **Markets:** There is a need for near real-time markets and reducing the lead time from 3 hours to 1 hour/30 minutes. Real time banking between states should also be enabled given the national importance of RE. Another stakeholder mentioned a study on RE grid integration from Agora Energiewende in the European context which noted the need for higher ramp rates and importance of market mechanisms and cross border electricity trade.

k. **Balancing location:** There is also a need to study the cost-effectiveness of the locational aspect of balancing RE, whether it should be done next to the RE project or at state level or national/international level.

l. **Distributed rooftop solar:** We are at present completely blind to the impact of distributed RE generation like rooftop solar PV on the grid and it is important to start some pro-active work on this issue before it becomes too large and out of control considering the large 40 GW target.

* * * * *

Prayas (Energy Group) contacts in this regard:

Mr. Ashwin Gambhir, ashwin@prayaspune.org ; Mr. Jatin Sarode, jatin@prayaspune.org

Annexure 1

Agenda

Time	Activity
9:45 - 10:15	Registration and tea
10:15 - 10:30	Welcome and introductory remarks by Ashwin Gambhir, Prayas (Energy Group)
10:30 - 11:00	Presentation by Mr. Ajit Pandit, Idam Infra Advisory Pvt. Ltd. on regulatory issues and challenges in wind & solar power forecasting, scheduling and DSM regulations
11:00 - 12.30	Discussion
12:30 - 12.45	Remarks by chairperson of the first session, Mr. Azeez Khan, Member, MERC
12:45 - 1:30	Lunch
1:30 - 1:45	Presentation by Ashwin Gambhir, Prayas (Energy Group) on emerging issues relating to RE integration
1:45 - 3:15	Discussion
3:15 – 3:30	Remarks by chairperson of the second session, Mr. Pankaj Batra, Member, Planning, CEA
3:30 – 3:35	Vote of thanks by Shantanu Dixit, Prayas (Energy Group)
3:35	Tea

* * * * *