Demand side management through Hydro URS in North-Eastern Region

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***Abstract*— NER grid faces the issue of high unpredictable generation during the 'peak-hydro' season throughout monsoon due to generation mix being in favour of hydro power. Major hydro plants in NER are Run-of-River (ROR) Plants with limited storage. ROR plants are must-run generating stations and sudden rainfall increases the water flow to create a huge surplus of power in the region. It is a challenge on the part of a state/beneficiary to carry out proper load forecasting for its control area. The unpredictable weather conditions make it difficult to maintain the balance between generation and demand. A mechanism is being proposed through this paper that will help the beneficiaries/ state for better real-time load-generation balancing.**

Keywords—URS, DSM, ROR

I. NOMENCLATURE

ROR	Run-of-River
RLDC	Regional Load Dispatch Centre
SLDC	State Load Dispatch Centre
URS	Un-Requisitioned Surplus
DSM	Deviation Settlement Mechanism
ISGS	Inter-State Generating Station
HEP	Hydro-Electric Plant
NER	North Eastern Region
CERC	Central Electricity Regulatory Commission
NERLDC	North Eastern Regional Load dispatch Centre

II. INTRODUCTION

In India, regional grids are operated by five Regional Load Dispatch Centres (RLDCs) as power pools with decentralized scheduling and dispatch. The State Load Dispatch Centres (SLDCs) shall have the total responsibility for regulating the net drawal of their control area from the regional grid close to their drawal schedules by controlling the demand. With the increasing demand for electricity, the requirement of reliable and efficient supply of power is of utmost importance.

Frequency is a real-time changing variable that reflects the balance between generation and demand. It is vital to maintain the frequency by the system operators close to 50 Hz at all times keeping a balance between generation and demand. Therefore, it is a fundamental indicator of the health of power system. Balancing and frequency control occurs over a continuum of time using different resources through the following measures:

- Primary control: Governor action by adjusting the energy input to the generator following a change in system frequency in seconds.
- Secondary Control: Automatic Generation Control (AGC) gathers information about an electric system, in particular system frequency, generator outputs, and actual interchange between the system and adjacent systems and makes adjustments to generation in minutes.
- Tertiary Control: Tertiary Control encompasses actions taken to get resources in place to handle current and future contingencies. Reserve deployment and restarting of available generating units following a disturbance are common types of Tertiary Control [1]. It also comprises adjusting the generation of units on bar based on system frequency and present and future anticipated demand in about a few minutes to within an hour.

Primary and Secondary controls are system controlled and tertiary control is being controlled by the system operator, the frequency of the system can be maintained largely by an increase and decrease in generation.

However, frequency close to 50 Hz does not mean that the load-generation is balanced across all control areas of an integrated grid. Individual deviations of different control areas may not be zero and there can be over-drawal or under-drawal by individual beneficiaries/state within their metered boundary in the system.

In India, there is no mechanism other than load shedding through which the positive deviation of individual control areas can be neutralized within a short time. Further, there can be under-drawl caused by surplus generation or load loss due to tripping of important elements like transformers, transmission lines etc. Due to the under-drawal or over-drawal from schedule, beneficiaries/state have to bear the monetary penalty for any deviation from their schedule as per the Deviation Settlement Mechanism(DSM). In this paper, an effort has been made to suggest a method to mitigate the aforementioned problem by decentralized control through the

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State Load Dispatch Centres (SLDCs) by sharing the hydropower allotted at that given time among the existing beneficiaries within existing regulatory framework.

III. PRESENT POWER SCENARIO

At present, India's total installed capacity is 363.367 GW (as on 30th Sept 2019). The share of hydro in India is 45.40 GW, which is about 12.5 % of the total all India installed capacity. However, hydro share in NER region is about 32.6 % of the installed capacity [2].

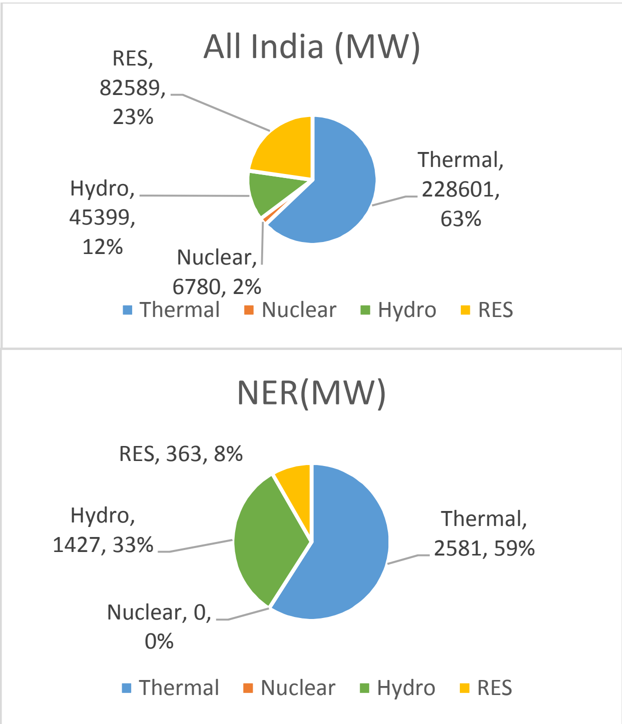

Fig. 1. Installed Capacity as on 30th Sept 2019

From the above figure, it can be portrayed that the hydro share of the total capacity is significantly higher in case of NER. Though the generation from the hydro is considered clean & pollution-free, there is limited flexibility of operation of hydro plants, unlike thermal plants. The generation of thermal plants can sustain variation as per the demand to an extent, but the same is not feasible for hydro plants. There are broadly two types of hydropower plants available in NER:

1) ROR (Run-of-River) Hydro Power is a system in which the flow of water takes place from a river through a penstock or a canal to spin a turbine and have little or no storage facility (a few hours of flow at most). Usually, a ROR project is used for Base Load capacity that provides a continuous supply of electricity, with some flexibility of operation for daily fluctuations in demand through water flow, which is regulated by the facility.

2) Storage Hydro Power is typically, a large system that uses a dam to store water in a reservoir. Electricity is produced by releasing water from the reservoir through a turbine, which runs a generator. Storage hydropower usually provides base load as well as can shut down and start-up at short notice according to the peak load demands of the system. It can also offer storage capacity to operate independent of the hydrological inflow for quite some time.

IV. NER GENERATION MIX

The North-Eastern Regional Power System comprises of seven North-Eastern states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura. There are 11 Inter-State Generating Stations (ISGS) in which two or more states have shares viz. AGBPP, AGTCCPP, Ranganadi, Kopili, Kopili Stg-II, Khandong, Doyang, Pare, Loktak, Palatana & BgTPP with a total installed capacity of 2872 MW and scheduling of these ISGS is being done by North East Regional Load Dispatch Centre (NERLDC). Among these ISGSs, AGBPP, AGTCCPP & Palatana are Gas based power plants (Total installed capacity of 1152 MW), BgTPP is Coal based power plant (Total installed capacity of 750 MW) and Ranganadi, Kopili, Kopili Stg-II, Khandong, Doyang, Pare, Loktak are Hydropower plants (total installed capacity of 970 MW). [2].

Out of the installed capacity of 970 MW hydro generation, 515 MW or 53 % of the total hydro generation is Run of River project. Though, NER being a hydro rich region, large scale multipurpose hydro projects are avoided in the region being a high seismic zone and various other aspects associated with it.

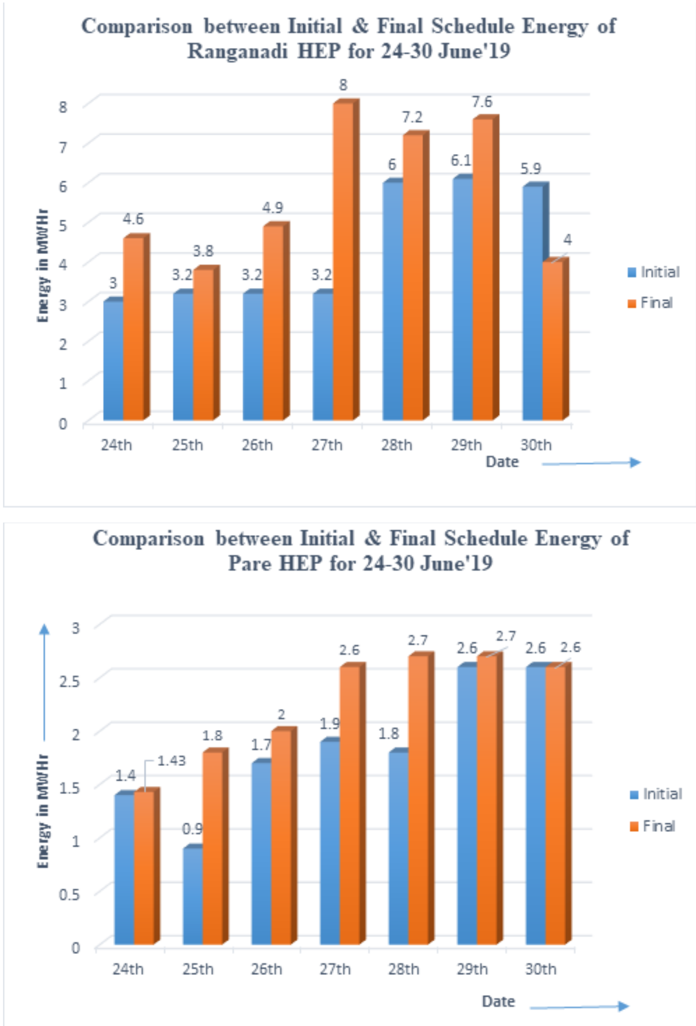

Fig. 2. Ranganadi and Pare HEP Day wise Generation

Most of the ROR type project have uncertainty of water flows during the rainy season, Fig. 2 depicts the change in energy within a day between Initial day ahead schedule and the Final Schedule for ROR, viz. Ranganadi HEP and Pare HEP, which leads to a sudden increase /decrease in the generation diverging from the actual demand requirement of the beneficiaries/states. The day-wise energy trend of Ranganadi HEP for the FY 2018-19 is shown in Fig. 3.

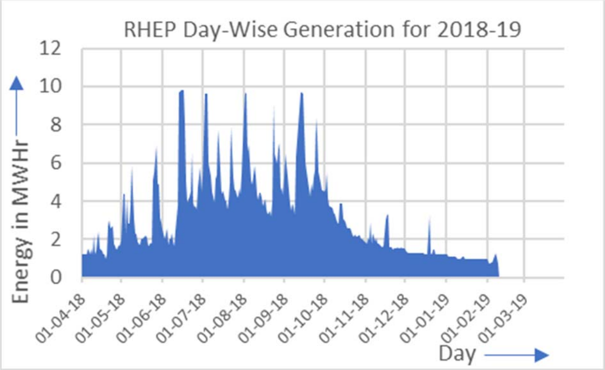

Fig. 3. RHEP Day-wise Generation

In case of the storage based HEPs, it is not always possible to hold excessive water for a long time, as it might lead to flooding of nearby areas of the reservoir and often leads to public outrage.

It has been observed that rainfall/flooding has a significant impact on electricity demand, which further increases the gap between supply and demand. Managing this twin problem of high supply and low demand in NER is often difficult at RLDCs & SLDCs end, even after backing down of all thermal and gas based generators upto their techno-commercial minimum. Upcoming ROR projects like Kameng Hydro Project (installed capacity of 600 MW) and Lower Subansiri Hydro Project (installed capacity of 2000 MW) will further lead to skewing of the NER generation mix towards hydro and escalate the problem of high generation and low demand during monsoon season.

As ROR Plants are must run generating stations, the flexibility of demand-side management within the existing regulatory framework is paramount for better optimization of resources among the beneficiaries.

V. Present Power MARKET Scenario

As per the Monthly Report on short-term transactions of Electricity for August 2019, about 85.8% of total Power supply in India is sourced through long term and medium-term power purchase agreements. 12% requirement of power demand is sourced through short-term transactions through bilateral agreements and by trading of electricity through energy markets. The remaining 2.2 % of sudden requirement or shortfall of power is met through the Deviation Settlement Mechanism (DSM) regulations of the Central Electricity Regulatory Commission (CERC)[3].

Currently, as per the existing volume limits for deviation, the beneficiaries/states may deviate from schedule up to 150 MW or 12% of the schedule, whichever is lower without additional penalty, when the frequency is between 49.85 Hz and 50.05 Hz. Beyond these frequency limits, no deviations are permitted.

Additional deviation from the schedule by beneficiaries/state and generators may cause them to pay additional deviation charges which is much higher than the prevailing unit price[4].

"Time-block" means a block of 15 minutes each for which Special Energy Meters record values of specified electrical parameters with first time-block starting at 00:00 Hrs with 96-time blocks in a day[4]. As per the present regulatory framework, the options to be explored by a beneficiary/state in order to reduce deviation from the grid in real-time is shown in Table I. From Table I, it is seen that there is no available measure to control the deviation from 1st-3rd Time Blocks. Here comes the necessity of a mechanism where the surplus beneficiaries/states can sell or offload the power to a deficit beneficiary/state immediately so that the amount of deviation from their schedules can be minimized without any change in the generation.

"Un-Requisitioned Surplus" (URS) is the reserve capacity in a generating station that has not been requisitioned and is available for despatch and is computed as the difference between the declared capacity of the generation station and its total schedule [5]. Therefore additional power is available for dispatch for the deficit beneficiaries/states if required. Under the present regulatory framework, URS power is only available for Coal & Gas based plants. However, URS power in hydro plants is not available for dispatch as the beneficiaries/states are scheduled full share of their power.

TABLE I. List of the remedial action available for beneficiaries/state

Time Block	**Remedial action by beneficiaries/states during**		**Limitations**
	Under-drawal	***Over-drawal***	
1st-3rd Block	Increase load	Decrease drawal from grid by load shedding	a. Have to bear the deviation. b. Increase of load is not. possible for generation surplus beneficiary/state. c. DSM charges for over-drawal or load shedding for deficit beneficiary/state.
4th Block onwards	Partial requisition from Coal & Gas plants	URS from Thermal plants	a. Depends upon the techno-commercial minimum of plant. b. URS availability.
6th Block Onwards	Sell through Bilateral transaction	Buy through Bilateral transaction	a. Depends on availability of buyer /seller.

This type of situation generally arises due to a sudden increase in power generation from ROR Hydro plants, sudden load crash in the state and sometimes due to both occurring at the same time. In such situations, beneficiaries/states can reduce their requisition from conventional generators after 4th-time blocks. However, many times even this does not help in reducing the under-drawal from the grid. Similarly, there can be a sudden deficit of power due to tripping of generating units and more load than anticipated and states must do load shedding to avoid deviation.

VI. Procedure of Hydro URS

The proposed procedure for URS in case hydro is as below:

1) If a surplus beneficiary/state wants to surrender its allotted power from the next time-block from a hydro ISGS, then it can apply for a partial requisition from the plant and it will be considered as hydro URS

power available to the other state/beneficiary which has got share allocations from that plant.

2) Partial requisition of the surrendering beneficiary/state shall not be implemented until another beneficiary/state applies for the URS power from that plant and the revision of schedule will be implemented from the next time block.

3) If the total quantum of URS is not availed by other beneficiary/state, the allocation remains unsold and power will be scheduled to the original beneficiary/state.

4) Original state/beneficiary can recall the URS anytime, giving one time-block notice.

5) Thus, the schedule of the Hydro ISGS will remain unchanged without violating the existing regulatory framework.

VII. Benefits of Hydro URS

The major benefits of sharing energy from Hydro plant through URS concept is as below:

1) Beneficiaries/states will have an immediate mechanism to manage deviation which is not present by design without changing the Generation Schedule of Hydro ISGSs.

2) Better resource utilization among beneficiaries/states and uncertainty in of Run-off River Hydro ISGSs would not affect the same.

3) Power surplus state/beneficiary can benefit by selling-off their excess power. Similarly, the power deficit state/beneficiary can also benefit by buying this cheaper power. A typical comparison of Variable Cost for different ISGSs of NER is shown in Fig. 4.

4) Both surplus and deficit beneficiaries/states can avoid DSM charges for over /under-drawal.

5) As power sold is exactly equal to power purchased and it is between states/beneficiaries, therefore, there is no loss for hydro ISGSs as they will get the schedule same as declared energy.

6) This is highly beneficial for the surplus state/beneficiary in case of bottleneck situation caused by transmission outages. This situation may lead to high under-drawal for the surplus state/ beneficiary which in turn leads to high deviation from the schedule.

7) Sudden under/over-drawal of power can be avoided without waiting for at least four-time blocks. This can be done very quickly as in this case no generation schedule is being changed.

8) The settlement is being done between the beneficiary/state and with no involvement of generators.

9) Costly Coal/Gas based power can be more efficiently replaced in real-time by Hydro URS.

10) In case of hydro generation linked with irrigation requirements in other regions, the actual backing down or closing down of units can be minimized if Hydro URS is availed.

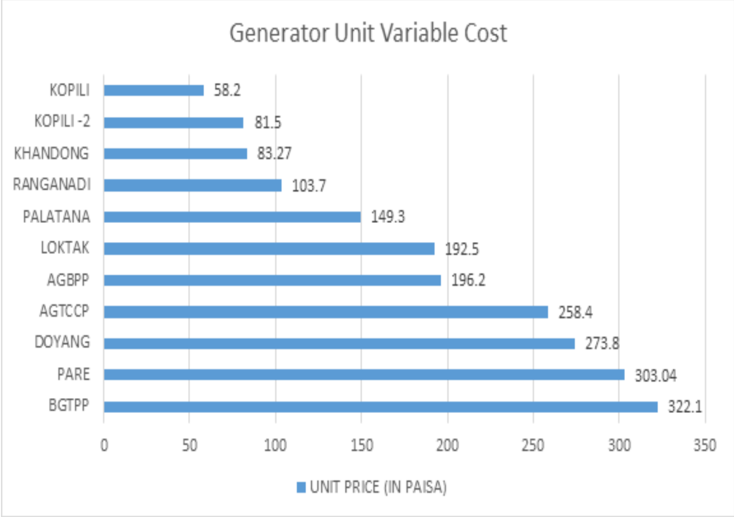

Fig. 4. Variable Cost in (Paise/unit) comparison among the ISGSs in NER.

VIII. CASE STUDY

A real-time case study on hydro URS has been considered with Assam and Arunachal Pradesh drawal pattern on 16th September 2019. The study had been done based on the SCADA data to evaluate the deviation from the drawal schedules. The deviation from schedule has been considered from 3rd to 11th time-block.

TABLE II. Deviation details of Assam and Arunachal Pradesh on 16th September 2019

Time Block	Assam	Arunachal Pradesh		Scope for Hydro URS (MW)
	Deviation (MW)	*Deviation (MW)*	*Hydro Schedule (MW)*	
3	56.9	-48.5	109.7	48.5
4	77.7	-51.5	109.7	51.5
5	70.8	-46.8	109.7	46.8
6	75.5	-47.2	109.7	47.2
7	47.4	-56.2	109.7	47.4
8	46.6	-59.0	109.7	46.6
9	64.5	-54.5	109.7	54.5
10	58.0	-58.2	109.7	58.0
11	40.2	-54.1	109.7	40.2

From Table II, it is clear that there is scope for Assam to avail hydro URS and minimize its over-drawal thereby reducing the deviation. This would provide respite to both Assam and Arunachal Pradesh from deviation charges along with financial gain.

IX. CONCLUSION

Beneficiaries/state can immensely benefit from the hydro URS mechanism for short time deviations with more flexibility without requirement for any change in the generation. The mechanism opens up opportunities to save cost through simultaneously availing hydro URS and surrendering power from coal power plants and this will increase the utilization of clean energy compared to the conventional sources. The mechanism of hydro URS can also be implemented pan India. The optimum use of cheaper energy resources can certainly reduce the variable or fuel cost of generator. In view of the above, the URS mechanism proposed for the hydro plants would play a crucial role in better demand-side management by beneficiaries/state.

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