Power System Operation and Control C2

System Control Room Preparedness: Today and in the Future PS1

10482_2022

Impact of Silt on Hydro Stations of Northern part of Indian Power System and Enhancing the Resilience in Grid Operation through near Real Time Silt Monitoring

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Motivation

- The Indian grid is one of the largest grid in the world having total installed capacity of around 392GW . India is also the fifth largest power producer in terms of hydroelectric power with more than 46GW of installed capacity.
- Majority of this hydro generation is concentrated in the Northern part of the country sourced by perennial rivers making generation available throughout the year.
- Due to high inflow of water, the rock and mineral particles in the river stream may damage the hydro turbine, guide vanes and runner blades. Due to this reason, hydro plants need to shut down their plants until the silt content reduces below permissible limits. This leads to sudden outage of large generation capacity in the grid, which is even more jeopardising at the time of high demand and poses challenge to the system operators to operate grid in secure and reliable manner.
- This paper tries to highlight the practises being followed in Northern region to effectively monitor the increasing silt content in river water and take advance actions in the increased lead-time available with them after utilisation of this near real time silt content monitoring tool.
- This paper also talks about two case studies highlighting the utilisation of this practise in effectively managing the grid during sudden hydro generation outage. One proposed methodology is also described for real time silt content monitoring data to develop the analytical tools for advance actions and enhancing the Indian grid resilience.

Challenges Faced

- The Indian grid has been demarcated in five regions namely Northern, Western, Eastern, Southern and North-eastern. Northern Regional's total installed generation capacity is around 108 GW. The thermal: hydro mix of Northern Region as per installed generation capacity is 62:20.
- Major hydro generating stations of Northern Region derive water input from snow fed rivers in the Himalayan Region, resulting in very low hydro generation availability during winter season whereas it continuously generates the power throughout the day during monsoon and summer months. Apart from this, hydro generation plays an important role to meet the peak demand of the day, provide operational flexibility to cater outage of thermal/ nuclear generation and also minimise the impact of RE (Renewable Energy) intermittency.
- Along with several advantages in real-time grid operation, hydro generation also brings its own set of challenges primarily sudden forced outage of machines due to high silt content in water intake. Silt is solid, dust-like sediment that water, ice, and wind transport and deposit in the river. Silt is made up of rock and mineral particles that are larger than clay but smaller than sand. The type of silt is tabulated below:

Average dimensions of silt particles (in mm)	Percentage	Class
0.62-0.031	3 to 5	Coarse Silt
0.031-0.016	25	Medium Silt
0.016-0.008	45	Fine Silt
0.008-0.004	25	Very Fine Silt
0.004 and below	0.5	Clay Fraction

Table I: Classification of Silt

- Due to inherent weak geology, rock instability, population explosion and deforestation, all rivers emanating from Himalayas carry enormous quantity of silt during heavy runoff of monsoon from June to September months. High silt content in river water intake increases risk of mechanical damage to hydro turbine, guide vanes and runner blades. Moreover, to avoid this risk, plant starts shutting down its unit when silt content reaches beyond permissible limits (say 5000PPM (particles per million)).

Silt Analysis at the Silt Collection Site

- Two methods followed by Hydro Plant-1 and Hydro Plant-2 for silt analysis at their sites are discussed. The Gravimetric method of silt analysis is being carried out by Hydro Plant-1 and coagulation method is being adopted by the Hydro Plant-2 for silt analysis at their respective sites. During the silt testing three silt components Coarse, Medium and Fine silt are analysed. The total time required for silt analysis in the Silt Lab is about 35 minutes to 60 minutes after receiving the sample in the lab. The Coarse content of silt is much more damaging to the machines as compared to the Medium and fine contents.

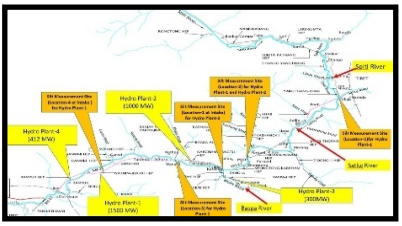

Figure I: Location of Hydro Plant and its Silt Measurement sites

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Protocol for Coordinated Generation reduction and silt flushing

- Hydro generation plays an important role in reliable grid operation and sudden outage of 3000-3500 MW of hydro generation due to high silt content in the water intake poses challenges to the system operator to operate the grid in a secure and reliable manner. To tackle impact of 3200 MW hydro generation outage on real time grid operation a protocol for coordinated generation reduction and silt flushing for the operation of Hydro Plant-1, Hydro Plant-2 and Hydro Plant-4 is tabulated below:

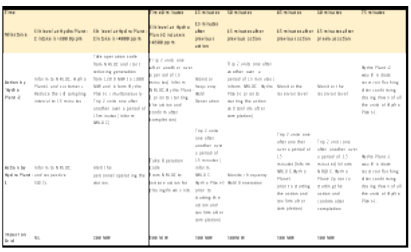

Table II: Location of Hydro Plant and its Silt Measurement sites

- Following are the benefits from implementation of the procedure of staggering of tandem hydro generation outage during high silt content. As soon as silt level crosses 3000 PPM, sampling rate is increased to analyse the prediction of silt trends (increasing or decreasing).
- In case of increasing trends, the system operators are able to plan necessary load-generation balancing during real time grid operations. The generation outage takes place in staggered manner based on increasing silt content as per above protocol which enables the system operators to operate the grid in secure and reliable manner in real time by ensuring sufficient ramp in generation from other plants.

Real time monitoring and utilization of Silt data

- Near real time silt measurement data is very helpful for system operators for timely assessment of hydro generation outage during monsoon season.
- Based on the inputs received from different locations, the near real time monitoring of silt is being done at control centers (Fig.II). This has resulted in better management of real time grid operation due to advance information of likely impact of silt on major hydro generation outage.

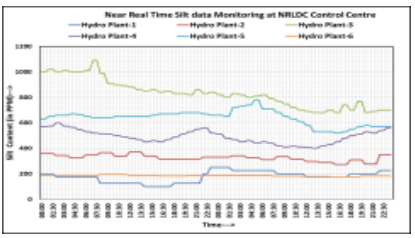

Figure II: Near real time silt content data for different locations

- The system operator starts taking actions, in case the silt content in river shows increasing trend and the plant is likely to be taken under outage after silt content crosses the permissible limit.
- Following advisory is issued by Regional load despatch centre to the constituents of Northern Region in view of increasing trends:

(1) All the state thermal/Hydro generations (units on bar) to be maximized to meet demand in view of anticipated outage of hydro plant due to high silt content. Margins to be kept in the network for safe operation.

(2) All the defense mechanisms like Restricted Governor Mode Operation (RGMO)/Free Governor Mode Operation (FGMO), Automatic Under Frequency Relay (AUFR), df/dt (Rate of change of frequency relay), System Protection Scheme (SPS) shall be in service and in healthy condition.

(3) Scheduling state hydro generation in an optimal manner to meet the demand during the outage of ISGS (Inter-State Generating Stations) hydro plants due to silt content. Meticulous demand assessment (15-minute wise basis) to be done so that load generation balance is maintained in all control areas.

(4) All reactive compensation devices to remain in service so that it may be operated to regulate voltages within IEGC (Indian Electricity Grid Code) band as per grid requirement.

Case study on 12th August, 2021

- A typical case of 12th August 2020, wherein advance time of 2 hours was available with system operators is described.
- From Fig.III, it can be observed that the first machine of Hydro Plant-2, Hydro Plant-1 and Hydro-Plant-4 were taken under outage at 06:56 hrs, 07:37 hrs and 07:36 hrs respectively when silt content at intake crossed 5000 PPM and subsequently other machines were also taken under outage.

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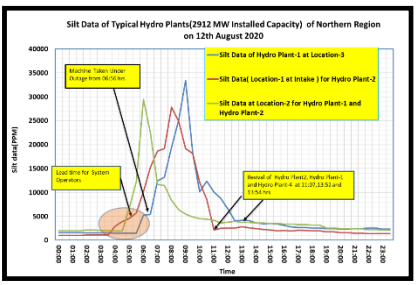

Figure III: Silt data Trend of Typical hydro Plant of Northern Region

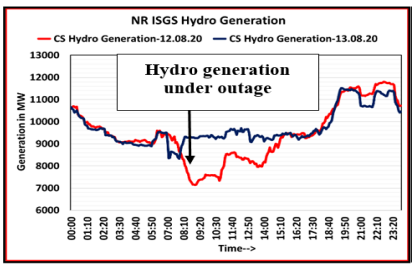

Figure IV: Northern Region ISGS Hydro Stations on 12.08.20 and 13.08.2020

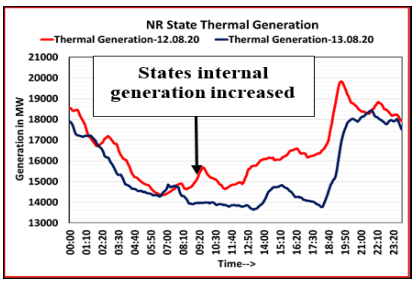

Figure V: Northern Region States Thermal Generation on 12.08.20 and 13.08.2020

Future Scope of Work

- In India, communication infrastructure has improved considerably and OPGW (Optical Fibre Ground Wire) communication is available in far flung areas of the Indian Power System. In future, automatic measurement of silt content at sampling location can be done and information can also be automatically communicated to the system operators at SLDCs and RLDC.
- It will further increase the lead time available with system operators and enable them to take prompt actions to minimise the grid imbalances.
- This data can also be used to further develop the analytical tools for advance actions. One proposed methodology (Fig.VI) which provides estimated silt content information based on several inputs such as Historical data of silt, Historical rainfall data, rainfall forecast data and near real time Silt content data etc. is depicted below. NRLDC is trying to carry out more research work in this area utilising Artifical Intelligence/Machine Learning based model to increase the lead time available with system operators.

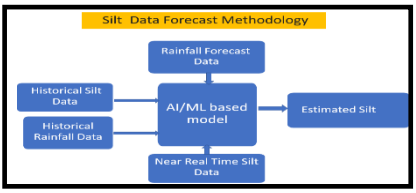

Figure VI: Silt data forecast Methodology

Conclusion

- The High silt content in river water pose challenges for smooth and efficient operation of hydropower plant and secure and reliable operation of grid. Near real time silt measurement data is proving very helpful for system operators for timely assessment of hydro generation outage during monsoon season which is also the high demand season for Northern region. This has resulted in better management of real-time grid operation due to advanced information of the likely impact of silt on major hydro generation outage. From the utilisation of this tool in several instances, we have seen that there is around 2-6 hrs lead time available for system operators to take advance planning actions for reliable and secure grid operation.
- With increasing penetration of renewable energy and their must-run status in the Indian grid, load generation balancing in case of sudden outage of hydro generation is day by day becoming more challenging to the system operators of the country. Better load-generation balance helps in maintaining grid parameters within prescribed limits and thereby also ensuring grid security. Further, staggered manner outage of plants during high silt condition as per available protocol enhances the resilience in grid operation. With an aim to increase the resilience of the power grid against high silt content at water in river, near real time monitoring silt data is being utilized by the grid operator which is proving extremely effective for Indian Power System. In future, this data can also be used to further develop the analytical tools for advance actions and enhancing the Indian grid resilience.