Success Story of India-Bangladesh Power System Operation

Saif Rehman, *MIEEE,* Rahul Shukla, *MIEEE,* Aman Gautam, *MIEEE*
Power System Operation Corporation Ltd (POSOCO)
New Delhi, India
saif.rehman@posoco.in

Md Arifur Kabir
Bangladesh-India Power Transmission Centre (BIPTC), PGCB
Kustia, Bangladesh
arifulkabir@gmail.com

Sharif Shamsul Alam
National Load Dispatch Centre, PGCB
Dhaka, Bangladesh
sde1.imd@pgcb.gov.bd

K V S Baba
Power System Operation Corporation Ltd (POSOCO)
New Delhi, India
kvsbaba@posoco.in

S. R. Narasimhan, *SMIEEE*
Power System Operation Corporation Ltd (POSOCO)
New Delhi, India
srnarasimhan@posoco.in

S.S. Barpanda
Power System Operation Corporation Ltd (POSOCO)
New Delhi, India
ssbarpanda@posoco.in

Sushil K. Soonee, *FIEEE*
Power System Operation Corporation Ltd (POSOCO)
New Delhi, India
sksoonee@posoco.in

***Abstract*—This paper follows the evolution of electricity grid interconnections between India and Bangladesh over time. The governance, policy, and regulatory framework facilitating the cross-border exchanges is elaborated. The power system scenario in terms of demand and generation of both countries is also discussed. The major operational aspects, viz. operational coordination, data & voice communication, scheduling & dispatch, reactive power management, protection aspects, system protection schemes, outage coordination, and resilience are examined. Future outlook for expanding the energy coordination between India and Bangladesh and the paper concludes with the benefits accruing due to cross-border interconnections.**

Keywords—cross border, trans-national, interconnections, India, Bangladesh, South Asia

I. Introduction

Every country and region has diversity in energy demand patterns and distribution of natural resources. Cross-border interconnections allow harnessing the opportunity for optimization of resource dispatch and strengthening regional energy security and resilience. India and Bangladesh are two of the fastest-growing world economies and this creates a high rate of energy demand growth. Successful and seamless energy cooperation between India and Bangladesh over the better part of the last decade creates a template for enabling more cross-border successes and synergies in the South Asian region.

Cross-border interconnections require assessment of multi-disciplinary aspects and their associated costs and benefits. Broadly, these considerations may be classified into technical, economic, financial, political, legal, social, and environmental aspects [1]. The approach adopted should be in consonance with the evaluation of these considerations. Across the world, the scope of cross-border interconnections varies, lying on the spectrum from small-scale power transfers to large-scale integration of power systems and electricity markets. An effective policy and regulatory framework is a key requirement for both countries to reap the benefits offered by cross-border trade. It can help in access to lower-cost resources, pooling of reserves, improving resilience, avoiding renewable curtailment. An NREL study found that import of 1 GW wind power from Tamil Nadu (India) would offset 3.4 TWh of peaking power from oil-based generation in Bangladesh, resulting in savings of US $175 per MWh substituted, while reducing CO_2 emissions by 5.5% at the same time [4]. An IRADe study modeling the 2030 and 2045 scenario concluded that import from India is the second most economical option for meeting future demand in Bangladesh, after coal-based generation [5]. It also found that both countries benefit from cross-border trade.

During 2019-20, the average generation cost in Bangladesh was BDT 5.91/kWh (USD 69.6/MWh) [12]. In India, the Average Pooled Purchase Cost (APPC) for 2021-22, as determined by the regulator is INR 3.85/kWh (USD 51.8/MWh) [14]. This difference provides a substantial impetus for undertaking cross-border interconnections for optimal dispatch of generation resources.

However, the overall actual cost of power import by Bangladesh is around BDT 6/kWh considering transmission charges on the Indian side, etc. Also, the cost of electricity for the next two upcoming cross-border power purchase agreements (PPAs) is more than BDT 7/kWh. One of these PPAs is already signed with a 1600 MW coal-based power station in India & another is negotiated and a letter of intent is already issued for 500 MW & 900 MW hydropower import from Nepal Indian grid (Modalities for such transfer of power are to be finalized). Furthermore, both of these PPAs have "take or pay" conditions which could restrict the optimal dispatch freedom of Bangladesh NLDC. For future cross-border power trade studies, these actual scenarios are needed to be incorporated for getting realistic results.

II. Cross-border interconnections

The signing of a Memorandum of Understanding (MoU) between India and Bangladesh on 11th January 2010 kickstarted electricity sector cooperation between the two countries.

2021 9th IEEE International Conference on Power Systems (ICPS) | 978-1-6654-2873-6/21/$31.00 ©2021 IEEE | DOI: 10.1109/ICPS52420.2021.9670352

The first cross-border link between India and Bangladesh was commissioned on 5th October 2013. It comprises a 98 km long, 400 kV double circuit AC transmission line between Behrampur (India) and Bheramara (Bangladesh) and a 500 MW HVDC back-to-back station at Bheramara along with associated equipment. On the Indian side, the 400 kV Behrampur substation was established through Loop-in-loop-out (LILO) of 400 kV Farakka-Jeerat line. On the Bangladesh side, LILO of 230 kV Ishurdi-Khulna double circuit line was done at Bheramara HVDC station to evacuate the power.

A second 500 MW HVDC block at Bheramara back-to-back station was commissioned on 10th September 2018, increasing the power transfer capacity to 1000 MW through the Behrampur-Bheramara link. A second 400 kV double circuit line between Behrampur and Bheramara to strengthen the interconnection and improve the reliability, has also been implemented and its first circuit was energized on 14th June 2021. The power system connectivity at Behrampur and Bheramara has also been strengthened over the years to support higher power transfers and to increase reliability.

After the installation of the second 500 MW HVDC block, Bheramara (HVDC station)-Rajshahi 230 kV double circuit line has been constructed to evacuate the additional power, and eventually, it has expanded and improved the Bangladesh transmission system.

Another interconnection between India and Bangladesh has been established from India's North-Eastern Region (Tripura state). A 63 km long, 400 kV double circuit line (operating at 132 kV) between Surjyamaninagar (India) and South Cumilla (Bangladesh) was commissioned on 17th March 2016. This link is operated in a radial manner, with loads in the Cumilla area of Bangladesh fed through this line. The maximum power flow over this link is restricted to 160 MW.

These links are facilitating up to 1160 MW export from India to Bangladesh. Figure 1 shows the cross-border interconnections between India and Bangladesh.

III. Power System Scenario

India has a total of 383 GW installed generation capacity (as of May 2021). The share of renewables in the Indian power system is growing with 95 GW grid-connected renewables and a target of having 450 GW renewables installed by 2030. Wind and solar penetration is generally around 10% in energy terms and its instantaneous peak, so far, is around 24%. The highest demand met in India is around 200 GW and the average daily energy consumption is around 4 TWh.

The total installed capacity in the Bangladesh power system is 22023 MW (as of April 2021, including cross-border import capacity). The grid-connected RE capacity at present is 129 MW, which is entirely Solar PV based. The bulk of the generation capacity comprises natural gas/LNG and furnace oil-based generation. While coal-based generation capacity is small at present (1728 MW), significant additions of coal-based capacity are planned. This includes an India-Bangladesh joint venture project with a capacity of 1320 MW. Nuclear capacity of 2160 MW is also under construction which is expected to go online in 2024. Fig 2 shows breakup of installed capacity for India and Bangladesh.

The peak demand served in Bangladesh so far is 13792 MW and the average daily energy met is around 195 GWh (2019-20). Around 9-10% of the energy requirement of Bangladesh is met through cross-border imports. The 2016 Power System Master Plan envisages that the demand would increase to 72 GW by 2041 [11]. Strengthening and augmenting the cross-border interconnections would help in meeting the demand growth with greater economy.

IV. Institutional and Governance Framework

Different countries start from different points and follow their own trajectories in the development of power systems. With different infrastructure designs, market designs, regulatory philosophies, practical challenges arise during planning and operation of cross-border links. Governance challenges can also crop up, resulting in more complications. Having an effective governance framework for the cross-

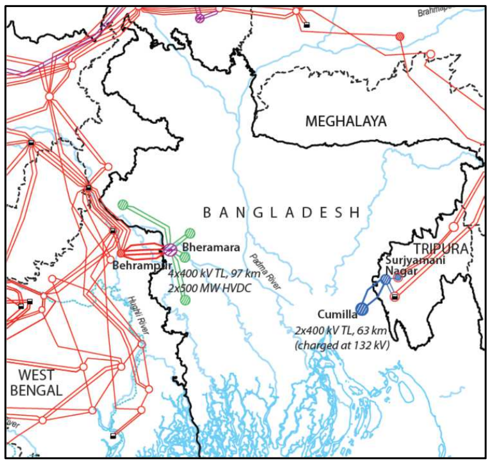

Fig 1: Cross-border interconnections between India and Bangladesh

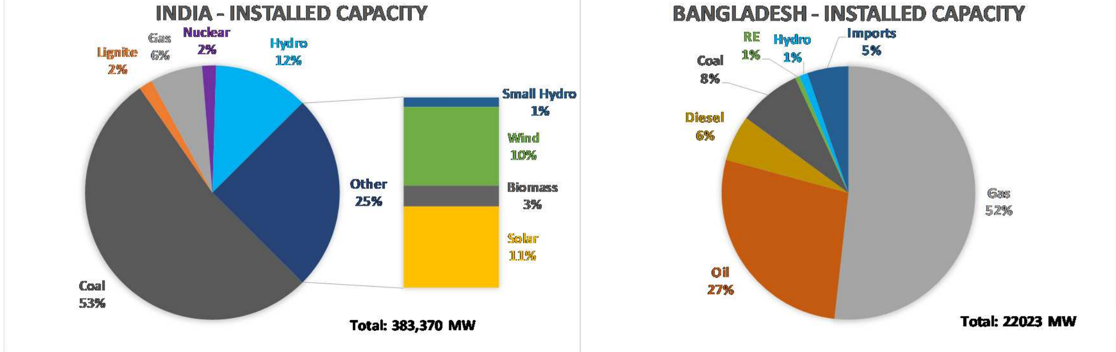

Fig. 2: Breakup of installed generation capacity in India and Bangladesh

border electricity cooperation helps in overcoming these challenges.

With the signing of MoU between India and Bangladesh, a Joint Steering Committee (JSC) and Joint Working Group (JWG) were constituted for reviewing and enhancing bilateral cooperation in the power sector between the two countries. JSC is led by the secretary power of the countries. The first activity taken up by the JSC/JWG was establishment of a cross-border link between the two countries. JSC and JWG meet periodically and decide the high level course of action for the electricity cooperation. JSC/JWG also constituted a Joint Technical Team (JTT) comprising of experts from both sides, which examines the various proposals from a technical standpoint and recommends the appropriate course of action to the JSC/JWG.

For review of operation of cross-border interconnections, Operational Coordination Meetings are held periodically between system operators and other stakeholders on both sides. Operational issues faced are discussed and subgroups for coordination on various operational matters – operational planning, outage planning, protection, scheduling, communication, etc. have been formed.

This framework has allowed energy exchange between India and Bangladesh to grow in a seamless and dispute-free manner. During FY 2020-21, the cross-border exchange was 7552 GWh (20.7 GWh/day). Since the commencement of cross-border exchange in Oct 2013, the total energy exchange is 38 TWh.

V. Policy and Regulatory Framework

In the initial period of development and operation of cross-border interconnections, a dedicated policy framework was yet to be formulated in India and a case-to-case approach was adopted in respect of transnational exchanges.

The Guidelines for Import/Export (Cross Border) of Electricity – 2018 were notified by the Ministry of Power, Government of India in December 2018 [8]. The guidelines seek to lay down an institutional framework and aim to enhance the transparency, consistency, and predictability in the policy and regulatory framework governing cross-border trades. Under these guidelines, Central Electricity Authority (CEA) has been identified as the Designated Authority (DA) for grant of approval for cross-border transactions and other functions laid down in the guidelines. CEA, in its role as DA, issued the procedure governing approval and facilitation of cross-border trades in February 2021 [9]. In line with this procedure, system operation level procedures are being finalized, which would serve to streamline and strengthen several operational aspects.

Cross Border Trade of Electricity Regulations were notified by Central Electricity Regulatory Commission (CERC) in March 2019 [10]. These regulations cover the roles and responsibilities of various stakeholders, requirements, and procedures for planning, connectivity, access, operation, settlement, and other aspects.

The India-Bangladesh cross-border power flow is still uni-directional and that is only from India to Bangladesh. However, Bangladesh will be able to export power to India after the completion of some ongoing power sector mega projects of Bangladesh. In that case, bi-directional power trade will be a reality and a necessary policy and regulatory framework will need to be formulated in this regard.

VI. Operational Aspects of India-Bangladesh Interconnection

Over the last eight years of operation of the India-Bangladesh interconnection, close coordination between the two countries on planning and operational matters has been established. Compliance with different regulations and technical standards has been ensured. Defense mechanisms for enhancing the reliability and resilience of the interconnection, have been designed and implemented. A robust and dispute-free accounting and settlement system is in place. The various aspects relating to the operation of the interconnection are as follows:

A. Real-time operational coordination:

Reliable operation of power systems requires an efficient and direct communication medium and protocols between control centres. The India-Bangladesh power system operation is coordinated from NLDC, India at New Delhi, and NLDC, Bangladesh at Dhaka. A system of exchanging operational codes is in place for facilitating switching of power system elements or change of power order on trans-national HVDC link. A separate code book is dedicated for exchanging real-time operational codes. The emergency events or events needing deliberation are shared via email with the other side followed by deliberations over phone.

B. Telemetry and data communication:

Real-time data telemetry (voltages, active/reactive power, frequency, switching device status) of cross-border stations, viz. Behrampur, Bheramara, Surjyamaninagar & Cumilla, is available with control centres of both countries. Continuous efforts are made by the SCADA engineers in India and Bangladesh to ensure uninterrupted telemetry & data communication at both ends. Any interruptions of outages of the data telemetry are regularly discussed in operational coordination meetings.

C. Synchrophasor Measurements:

A Phasor Measurement Unit (PMU) has been installed at Behrampur substation on the Indian side at 400 kV level. Control room operators can monitor the transients, oscillations, faults, etc. in real-time through PMUs installed on the 400 kV Bheramara lines.

D. Voice Communication:

A dedicated voice communication link has been established for real-time coordination and system operators on both sides are able to easily interact on operational issues. A dedicated optical fiber path provides secure and reliable communication. In addition to NLDC India and NLDC Bangladesh, the voice communication link is also extended to Eastern and North-Eastern Load Despatch Centres (ERLDC & NERLDC), Tripura State Load Despatch Centre, and cross-border substations.

E. Scheduling and Dispatch:

Power exchanges through the 400 kV Behrampur-Bheramara link are scheduled by NLDC-India, in line with the timelines as per Indian Electricity Grid Code (IEGC). Government of India has allocated 250 MW quantum from 13 inter-state generating stations across three regions of India, to Bangladesh. In addition to this quantum, Bangladesh has entered into contracts with other sellers in the Indian power market, which are scheduled under the Long Term Access (LTA) mode. Bangladesh is also participating in India's short-term electricity market. The final drawal schedule encompassing all above transactions serves as the guideline for the operation set point of the cross-border HVDC.

F. Metering and settlement

Interface energy meters are installed at all the interconnection points between the countries for recording the actual net import/export MWh and MVArh for every 15-minute time block. The energy accounting process operates on a weekly cycle. NVVN has been designated as the nodal agency for cross-border trading of power with Bangladesh.

G. Deviation settlement

Any inadvertent deviations from schedule are settled as per CERC Deviation Settlement Mechanism Regulations, 2014. As per the requirement of CERC Cross border regulations, NVVN has been identified as Settlement Nodal Agency (SNA), which takes care of the settlement of various contracts and regulatory accounts on behalf of Bangladesh. SNA plays a very important role, acting as an enabler for cross-border electricity transactions, settling deviations through back-to-back arrangements, and acting as a buffer between two different market mechanisms.

H. Reactive Power Management:

The synchronous connection via 132 kV lines introduced the requirement of reactive power management across the AC link. The reactive drawal over 132 kV Surjyamaninagar-Cumilla D/C, as measured on the Indian side varied around 70-80 MVAR during summer. The power factor over the link was observed to remain below 0.95 for 65% of the time during one year. This was posing a constraint due to deterioration of voltage profile in Tripura system and measures to alleviate this problem were therefore discussed in operational coordination meetings. The same issue was also faced on the Bangladesh side with low voltage at Cumilla (117-118 kV) during peak load conditions. On the Bangladesh side, 33 kV, 4x12.5 MVAR capacitor banks were installed at Cumilla. On the Indian side, the nearby generating units were instructed to inject reactive power to support voltages. Mutual coordination helped in designing a system protection scheme for the purpose.

I. Protection Coordination:

The design of protection scheme for any AC transmission system requires intense coordination between both ends. In case of India-Bangladesh AC links at 400 kV as well as 132 kV, coordination for protection-related issues was smoothly carried out. In case of tripping of any line, the fault clearance time was checked from readily available synchrophasor data. The fault clearing time provided an indication of fault getting cleared by primary protection or backup protection. In case the fault was cleared by backup protection, the details were investigated by both sides. The adopted relay settings on both sides as well as the network topology were then reviewed to identify the cause and decide upon remedial measures. The coordinated efforts helped in ensuring the healthiness of the protection scheme.

J. Sharing of tripping information:

Sharing tripping details is very important for analyzing grid incidents and identifying any shortcomings. Disturbance recorder (DR) and Event Logger (EL) outputs are essential to understand the root cause and to take preventive actions against recurrence of the same in the future. To facilitate sharing of all relevant information and data, a web-based tripping portal for all cross-border links between India and Bangladesh has been created. The details of tripping of cross-border links from utilities on both sides are uploaded in the portal along with first information reports, relay indications, DR and EL outputs on in a timely manner, which are available to system operators on both sides for analysis.

K. System Protection Schemes (SPS):

System protection schemes were also designed and implemented to limit the impact of tripping of cross-border links on the reliability of the power system on either side. Suitable schemes were designed for the HVDC Back-to-Back link as well as the 132 kV AC transmission line. The SPS on HVDC side consisted of runback of HVDC link when the AC side voltage reduces below a certain threshold, frequency of the Indian system falls below a certain value, outage of AC line connected to HVDC, etc. The operation of SPS occurred on very few occasions and adequate SPS-based actions helped in ensuring the reliability of the network.

On the trans-national AC link, SPS were designed to take care of the transmission constraints. The scheme involved load shedding on the Bangladesh side whenever constraints were observed on the Indian side of the grid. The SPS was implemented via coordination from both sides and it helped in ensuring reliability whenever the constraints were observed on either side. SPS schemes were regularly monitored by both sides and periodic modifications were also carried out on case to case basis.

L. Outage Coordination:

Outage management is one of the critical aspects of operational planning. The maintenance outages of power system elements need to be planned to ensure minimum impact on the reliability and security of the grid. The load pattern, voltage, weather, redundancy, and power flow-related aspects need to be considered before approving any request for a power system element outage. An annual outage planning process with a monthly review is in place in India. As per standard practice, any utility needs to apply to the appropriate RLDC three days in advance for availing outage of any element. The same practice is followed in the case of transnational links between India and Bangladesh. Efforts are made to club outages of associated systems together, in order to minimize the impact on power transfers. For emergency outages, necessary actions are taken in advance like load-flow based reliability study and associated remedial measures in the nearby network. The revision in schedules of import/export is also implemented in such conditions. These practices help in the timely resolution of outage requests as well as maintaining reliable operation.

M. Transfer Capability:

Total transfer capability (TTC) is the maximum amount of power that can be transferred reliably over the interconnected transmission system considering the worst credible contingency. The transfer capability for the India-Bangladesh interconnection through HVDC is assessed by reliability coordinators of both countries considering the constraints in the respective countries. As of date, TTC for power flow from India to Bangladesh through HVDC Bheramara is 1000 MW, and through 132 kV Surjyamaninagar - Cumilla D/C is 160 MW. NLDC India declares TTC on monthly basis and revises it in real-time in case of any planned/forced outage.

N. Resilience:

The Bay of Bengal region witnesses the development of many cyclonic storms every year, which impact both India and Bangladesh. In the last few years, the major cyclones are Amphan, Fani, Phailin, Bulbul, and Titli. These cyclones carry gusts of high-speed wind and are a potential threat to power system elements falling in their path. They are known to cause severe damage to the transmission and distribution network. Cyclones are also associated with sudden load crashes and high voltage conditions in the power system. It becomes very important that all entities where the cyclone is expected to pass through coordinate to take advance measures. During all the cyclonic events, action plans to prepare for and manage the power system are prepared and disseminated. With respect to cross-border exchanges, necessary actions like proper scheduling of generators, varying HVDC set point, managing voltages, etc. are taken. The cooperation helped in handling these extreme weather events.

In the HVDC station power flow is controlled by 12-pulse light-triggered silicon-controlled rectifier. This system has fast switching capacity by which power flow can be controlled with a ramp of 50MW per minute. This ramp mode is very effective in maintaining grid stability in case of weather disasters. The HVDC back-to-back station can also be used for frequency control (which is a built-in feature of this system) to enhance frequency controllability & stability of the Bangladesh grid system.

VII. Experience of Operation of Cross-Border Interconnection

Imports from India help in displacing costlier oil-based generation in Bangladesh. Over the years, the quantum of power exchange has grown, from around 150 MW in 2013, to around 1160 MW today (Fig. 3). The trend of cross-border exchanges tends to follow the seasonality in Bangladesh demand. During the winter season (Nov-Mar), the average power import remains lower, around 400-500 MW, and it varies during the day, increasing during peak hours (5 pm to 11 pm in Bangladesh). During the rest of the year, the import generally remains at the full capacity of around 1100 MW round the clock (Fig. 4). The power flow from Bheramara, being a controllable HVDC link, is generally fixed, while the power flow in 132 kV Surjyamaninagar-Cumilla lines varies with change in demand. HVDC Bheramara is equipped with frequency control mode of operation also, though it is not enabled in day-to-day operation.

The frequency range for normal operation as per Indian Electricity Grid Code is 49.90-50.05 Hz (50 Hz +0.1%/-0.2%), while as per Bangladesh Electricity Grid Code, the normal frequency range is 49.50-50.50 Hz (50 Hz ±1%). The peak demand in the Indian power system is 200 GW and for Bangladesh, it is 13 GW. The frequency pattern and geographical placements of both power systems indicate scope for reliability and economic benefits to both countries by augmenting the interconnection capacity.

On 24th May 2021, the Bangladesh power system experienced an unprecedented scenario where all east-west interconnections of the Bangladesh grid got tripped and the Bangladesh transmission system was split into two separate regions running on their own. It is to be noted that for the role of HVDC imported power (909MW) and the contribution from a 660 MW coal-based power station unit of Payra power hub (600MW) at Bangladesh side, no black-out or brown-out happened in the Western part of Bangladesh and the Eastern part as well. Thus interconnection with India helped the Bangladesh system immensely during this event.

VIII. Future Outlook

The Northern part of Bangladesh has some geological difficulties to implement power plants. To overcome these difficulties 400 kV transmission line construction project is ongoing at Rahanpur-Monakasha border to collect power from an upcoming 2x800 MW (net 1496 MW) coal-fired thermal power plant in Godda District of Jharkhand State in India to the national grid of Bangladesh through Chapainawabganj District [15]. This will assist with satisfying the developing force need in Rajshahi and Rangpur district which is the rural agricultural financial focal point of Bangladesh. The generation would be evacuated directly to Bangladesh through a dedicated transmission line. This would serve as another type of model for cross-border interconnections in South Asia.

A 765 kV Bornagar (Assam, India) – Parbatipur (Bangladesh) – Katihar (Bihar, India) line is being implemented which would connect Bangladesh with India's Eastern and North-Eastern regions. This would provide the opportunity to establish synchronous interconnection between India and Bangladesh. In addition to providing additional transfer capacity to Bangladesh, it would strengthen the

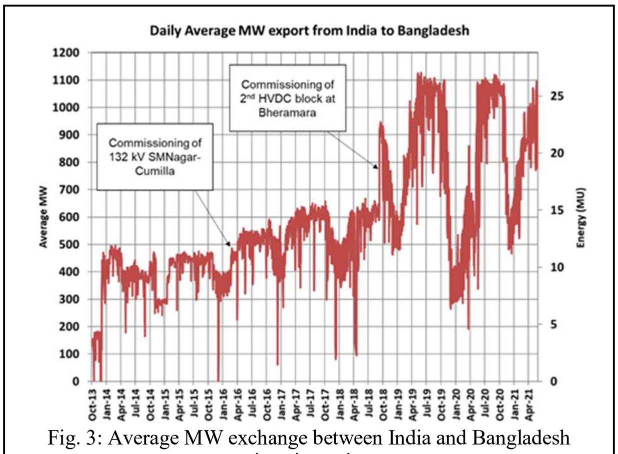

Fig. 3: Average MW exchange between India and Bangladesh since inception

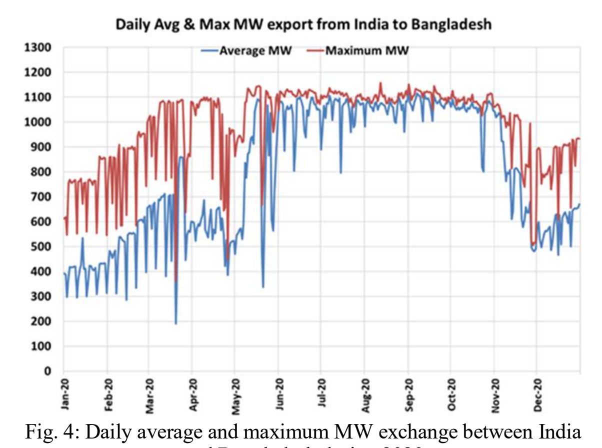

Fig. 4: Daily average and maximum MW exchange between India and Bangladesh during 2020

interconnection between India's Eastern and North-Eastern regions. Points for further interconnection between India and Bangladesh are also being identified.

IX. Conclusion and Way Forward

The successful operation of cross-border interconnections between India and Bangladesh forms the groundwork for greater energy cooperation in the South Asian region. It provides opportunities for utilities to participate in sub-continental electricity markets. It helps in the optimization of generation resources and promotes region-wide economy.

A key enabler for this success has been the cooperative governance structure put in place by both governments. The policy and regulatory framework established by the Government of India and CERC helps in streamlining the critical aspects associated with cross-border trades. The continuous engagement between the two countries at various levels – governmental, planners, and operators, is acting to smoothen out the bumps and chart a clear roadmap for deepening the energy cooperation in a more meaningful way. In addition to economy, this would help in improving energy security, enhancing the reliability and resilience of power systems, which would ultimately lead to improvement in societal well-being.

With further growth of the Bangladesh power system, enlargement of the scope of participation in regional electricity markets may also be considered. At present, the participation of Bangladesh in Indian power markets is limited to OTC transactions. This can be expanded to enable participation through collective transactions in day-ahead and real-time markets.

In the case of hydropower trade within the South Asian region, a robust water-sharing agreement among the regional countries would help to ensure sustainability. An understanding on water-sharing issues between countries sharing common river systems would also give a fillip to the exploitation of hydropower potential and cross-border trade.

Cross-border power trades by using the seasonal demand-generation diversity among South Asian countries are a potential area that may also be explored to enhance cooperation and mutual benefit.

Synchronous interconnection in the future would lead to an enhanced footprint of the sub-continental power system, greater stability, sharing of reserves, larger market footprint, and ability to integrate more renewables, thus reducing the carbon intensity of electricity generation.

Acknowledgment

The authors are grateful to the power system fraternity, PGCB and POSOCO Management for their encouragement. The views expressed in this paper are those of the authors and not necessarily of the organization they belong to.

References

[1] United Nations (2006). *Multi dimensional issues in electric power grid interconnections* [Online]. Available: https://sustainabledevelopment.un.org/content/documents/interconnections.pdf

[2] A. Singh, T. Jamasb, R. Nepal, and M. Toman, *Cross-Border Electricity Cooperation in South Asia* (2015,June 23). World Bank Policy Research Working Paper No. 7328. [Online]. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/22206/Cross0border0e0ration0in0South0Asia.pdf

[3] SARI/EI (2018). *Assessment of Socio-economic Impacts of CBET in Bangladesh* [Online]. Available: https://sari-energy.org/wp-content/uploads/2018/09/Final-Revised_Assessment-of-Socio-Economic-Benefits-of-CBET-in-Bangladesh.pdf

[4] NREL (2020). Simulation of Cross-Border Renewable Energy Trading in South Asia [Online]. Available: https://www.nrel.gov/docs/fy20osti/77029.pdf

[5] IRADe (2017). *Economic Benefits of Bangladesh–India Electricity Trade* [Online]. Available: https://irade.org/Analytical%20Study%20Economic%20Benefits%20of%20Bangladesh-India%20Electricity%20Trade.pdf

[6] D.J. Hurlbut, and S. Koebrich (2019). *Regulatory Foundations for Cross-Border Electricity Trading: Bangladesh* [Online]. Available: https://www.nrel.gov/docs/fy20osti/75228.pdf

[7] D.J. Hurlbut, and S. Koebrich (2019). *Regulatory Foundations for Cross-Border Electricity Trading: India* [Online]. Available: https://www.nrel.gov/docs/fy20osti/75229.pdf

[8] Ministry of Power, Government of India. (2018). *Guidelines for Import /Export (Cross Border) of Electricity* [Online]. Available: https://powermin.gov.in/sites/default/files/uploads/Guidelines_for_ImportExport_Cross%20Border_of_Electricity_2018.pdf

[9] Central Electricity Authority. (2021) - *Procedure for Approval and Facilitating Import/Export (Cross Border) of Electricity by the Designated Authority* [Online]. Available: https://cea.nic.in/wp-content/uploads/2021/02/Final_DA_Procedure_26022021.pdf

[10] Central Electricity Regulatory Commission. (2019). *Cross Border Trade of Electricity Regulations* [Online]. Available: https://cercind.gov.in/2019/regulation/CBTE-Regulations2019.pdf

[11] Power Division, MPEMR, Government of Bangladesh. (2018). *Revisiting PSMP 2016* [Online]. Available: https://solar.sreda.gov.bd/doc/Revisiting%20PSMP%202016%20(full%20report).pdf

[12] Bangladesh Power Development Board (2020). *Annual report: 2019-20*. [Online]. Available: file:///C:/Users/saif/Downloads/annualreport_1605772936_AnnualReport2019-20.pdf

[13] S.K. Soonee, V.K. Agrawal, S.R. Narasimhan, T. Kumar Roy, P.K. Roy, Paper No. 323 on *India-Bangladesh cross border exchanges through high voltage direct current (HVDC) back-to back Station - A Success Story*. CIGRE Lund Symposium, 2015. [Online]. Available: http://www.e-cigre.org/

[14] Central Electricity Regulatory Commission (2021). *Calculation of Average Power Purchase Cost (APPC) rate at the national level* [Online]. Available: https://cercind.gov.in/2021/orders/01-SM-2021.pdf

[15] Power Grid Company of Bangladesh (2021). *Ongoing Projects.* [Online]. Available: http://www.pgcb.gov.bd/site/page/fba3b4d7-5122-4e1d-8d5a-592b02582e67/-