Minutes of the 3rd meeting (Virtual) of SAFIR Joint Working Group (JWG) "To study, formulate and recommend for facilitating Power trade development in South Asia" held on 28th January 2021 at 04:30 PM IST

Deputy Chief (Regulatory Affairs) Central Electricity Regulatory Commission (CERC), India welcomed all members to the third meeting (Virtual) of SAFIR Joint Working Group (JWG) ***(Appendix-I)*** on the said subject and provided a brief on the agenda of the meeting.

Agenda 1: Nomination of Chairperson for the Joint working Group

Deputy Chief (RA), CERC informed the members of the JWG that this Working Group had initially selected Chairperson of PUCSL Sri Lanka as the Chairman of this JWG. However, subsequently, SAFIR Sectt had received a communication from PUCSL which stated that the new Chairperson of PUCSL was yet to be appointed. Therefore, in light of the same, this Working Group needed to nominate any other member of this JWG as the Chairman of the JWG.

In response, Member, CERC proposed that CEO, Bhutan Electricity Authority may be nominated as Chairman of the Joint Working Group. This proposal was agreed by all the other members and CEO, BEA consented to be the Chairman of the Working Group .

Agenda 2: Confirmation of minutes of 1st Meeting held on 28.09.2020

Deputy Chief (RA), CERC informed the members about the different agenda items which were discussed and the action points identified in the 2nd meeting of the JWG held on 28.09.2020. Thereafter, Chairman of the JWG sought for confirmation of the minutes of the 2nd meeting. After approval of the members, the minutes of the 2nd meeting of JWG were confirmed.

Agenda 3: Harmonization of Rules and Common Minimum Grid Code - Presentation by IRADe

Project Director and Technical Head of SARI/EI, IRADe made a presentation on Harmonization of Rules and the Common Minimum Grid Code ***(Annexure – I)*** . The presentation highlighted the Common Minimum Grid Code based on the regulations, grid codes and procedures across different countries in South Asia.

Member, CERC observed that the connection code did not indicate as to who will apply for the connection because Governments of the two or more countries are involved to which Project Director , IRADe clarified that the code was technical in nature and thus the Generator and the consumer etc. could apply for connection. However, the applications should be routed through the Government only. Further, it was highlighted that the countries on the periphery of India have smaller systems, as compared to India and thus the fault level in these countries are lesser than that in India. It was also suggested that the interconnection points should also have fault current limiters. This would also enable all the countries to continue with existing breakers.

Member , Bangladesh ERC enquired about whom and at what level would be considered as the single point of contact to which Project Director , IRADe clarified that presently , the JWG (which is at Government level) is handling all the coordination. Therefore, the JWG may call the transmission utility and the system operators for interaction. Subsequently, in the near future with

increased number of interconnection points and enhanced cross border trading, different levels of point of contacts can be discussed at Transmission level, System Operator level contacts in addition to the Government level and Regulators level .

Senior Advisor, World Bank enquired whether the wish list related to compliance, method of working, discipline etc. indicated in the document lies within the domain of the regulators in all the countries or whether there is gap between countries to which Project Director , IRADe clarified that various regulators are at different level of evolution. Thus they are either empowered or are getting empowered. Mr. Shahi suggested that an Annexure to the report may be provided with scope which completely lies within the Regulators preview in all the countries alongwith those where gaps are identified as this topic may arise during subsequent discussions.

Chief (Regulatory Affairs), CERC and Convenor of JWG suggested providing time to the members to reflect on the report and submit their suggestions to the SAFIR Secretariat after consultation with various organisations within their respective countries and provide their consolidated suggestions.

Agenda 4: Electricity market design – International perspectives - Status update by World Bank wrt synthesizing the same with studies conducted by IRADe

Senior Energy Specialist , World Bank made a presentation on the Electricity market design – International perspectives **(Annexure -II) .**

Chief (RA), CERC informed the members that India has experimented with number of market designs and number of initiatives such as security constrained economic dispatch. The World Bank can thus, help each of the member countries to experiment with security constrained economic dispatch or any other similar mechanism which leads to optimisation of resource in their own countries . Subsequently, the system can move towards a regional system for optimisation of resources at the regional level.

Member, Bangladesh ERC suggested that the terms of reference for the consultant indicated in the Report can be given an in-principal endorsement. However, Chairman, ERC Nepal suggested discussing the report and terms of reference within their organisations/ friend organisations and provide their suggestions.

The Chairman of the JWG suggested that time should be provided to the member countries for their suggestions on the report and the terms of reference provided therein.

Decision Points & Way forward

1. The members of JWG shall provide their comments/ suggestions on the Report including the Terms of Reference therein to the SAFIR Secretariat.

2. SAFIR Secretariat shall compile the comments/suggestions received from members of JWG and inform IRADe and World Bank to compile and incorporate the same in both the reports .

3. The date of the next meeting will be mutually decided .

The meeting concluded with vote of thanks to Chair.

Appendix - I

List of Participants of the 3rd meeting (Virtual) of SAFIR Joint Working Group (JWG) "To study, formulate and recommend for facilitating Power trade development in South Asia" held on 28th January 2021 at 04:30 PM IST

S. No.	Name & Designation	Organisation
01	Mr. Samdrup Thinley, Chairperson/CEO,	JWG/ BEA, Bhutan
02	Mr. I.S Jha, Member	CERC, India
03	Mr. Mohammad Bazlur Rahman, Member	BERC, Bangladesh
04	Mr Dilli Bahadur Singh, Chairperson,	ERC, Nepal
05	Dr. S K Chatterjee, Chief (Regulatory Affairs) and Convenor	CERC, India
SPECIAL INVITEES		
06	Mr. RV Shahi, Sr. Energy Advisor	World Bank, Europe
07	Mr. Gailius J. Draugelis, Lead Energy Specialist, Energy Sector Unit South Asia Infrastructure	World Bank, US
08	Mr. V Menghani Chief (Engineering)	CERC, India
09	Mr Damitha Kumarasinghe, Director General	PUCSL, Sri Lanka
10	Mr. Sonam Darjay, Chief, Licensing & Technical Division	BEA, Bhutan
11	Mr. CFK Mussaddeq Ahmed, Director (Power)	BERC, Bangladesh
12	Mr. Md Adil Chawdhury, Superintending Engineer, Planning division	Power Grid Company of Bangladesh
13	Mr. Pankaj Batra, Project Director	SARI/EI, IRADe, India
14	Mr. Rajiv Panda, Technical Head	SARI/EI, IRADe, India
OTHER PARTICIPANTS		
15	Mr. Gamini Herath, Deputy DG	PUCSL, Sri Lanka
16	Mr. Nalin Edirisinghe, Director Licensing	PUCSL, Sri Lanka
17	Mr. Kanchana Siriwardena, Director Tariffs & Economic Affairs	PUCSL, Sri Lanka
18	Mr B M Chalith Pasindu, Asst Director,	PUCSL, Sri Lanka
19	Mr Debabrata Chattopadhyay, Senior Energy Specialist	World Bank
20	Mr Salman	World Bank
21	Ms. Rashmi Nair, Deputy Chief (Regulatory Affairs)	CERC, India
22	Mr. Arun Kumar, Assistant Secretary (SAFIR)	CERC, India
23	Mr. Ankit Gupta, Research Officer (FOR)	CERC, India

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SARI/EI

IRADe Integrated Research and Action for Development

South Asia Regional Initiative for Energy Integration

Annexure -1

Presentation

on

Harmonisation of Rules and Common Minimum Grid Code (CMGC) for South Asia

Presented by

Mr. Pankaj Batra & Mr. Rajiv Ratna Panda

SARI/EI/IRADe

3rd meeting of the Joint Working Group(JWG) of SAFIR "To study, formulate and recommend for facilitating Power trade development in South Asia" (Virtual Meeting), 4.30 PM IST onwards , through Video conferencing, Thursday , 28th January 2021, New Delhi, India

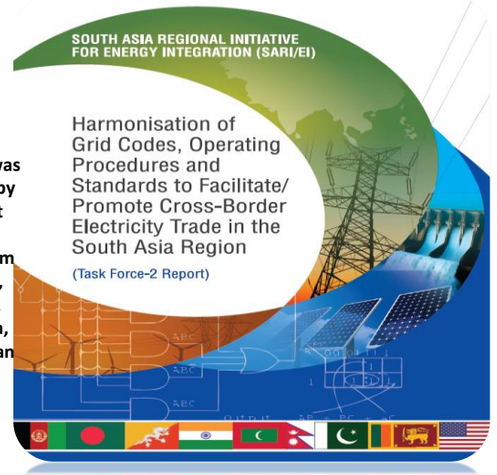
Contents

Need for Harmonisation Rules and SARI/EI Past Work

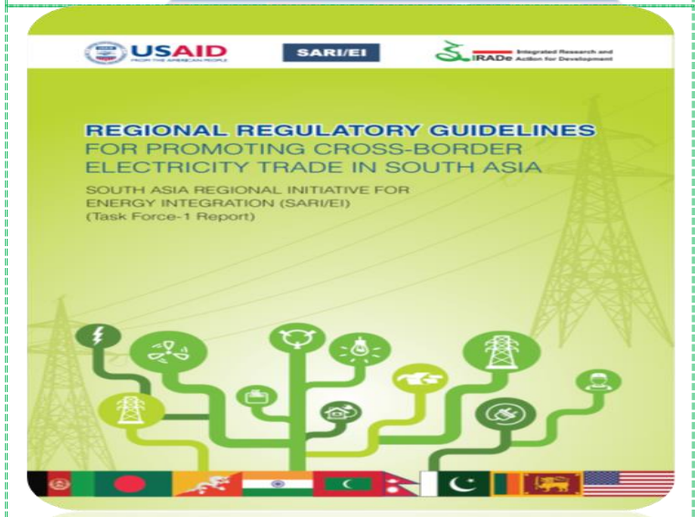
Need for Harmonization of Rules, Grid Codes and SARI/EI Past Work

- South Asia (SA) countries are at different stage of power sector evolution in terms policy, regulatory and legal frameworks.
- Any regional market design will need to have some basic **technical rules** to be commonly followed by the SA countries for market to function smoothly in a transparent , fair and competitive manner.
- SARI/EI has recognized this need a long time back, worked on many areas to related harmonization of policy, legal and regulatory framework among SA countries over last 8 years.
- Earlier published **regional regulatory guidelines** and as well as comprehensive report on **Harmonization of Grid codes, Operating Procedures and Standards to facilitate/promote Cross-Border Electricity Trade** in the South Asia Region-Framework Grid Code Guidelines.
- By building upon the past work and taking forward various initiatives, we have developed The **Common Minimum Grid Code for South Asia**.

Task Force-2 Report on Harmonisation of Grid codes, Operating Procedures & Standards to facilitate/promote CBET in South Asia Region



Task Force-2 was represented by Government Nominated Members from Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan & Srilanka.



Common Minimum Grid Code (CMGC) for South Asia

Common Minimum Grid Code for South Asia

- The Common Minimum Grid Code for South Asia lays down the rules, guidelines and standards to be followed by various South Asia country participants in the system for cross border trading in electricity, while operating the power system, in the most secure, reliable, economic and efficient manner.

Applicability and Organizational Framework

- Applicable to all countries of South Asia, who get connected to the South Asia grid through a ***synchronous*** or ***a-synchronous*** (i.e. HVDC) connection.

- Each country will initially be represented by a **single point of contact** for the initiation of implementation of the Common Minimum Grid Code.

- Single point of contact will be supported by the **relevant Ministry** dealing with power, the **Regulator** of the respective country, the **transmission agency** of the respective country, the **system operator** of the respective country and the **accounts settlement/market operator** of the respective country.

Organizational Framework

- Later, to formalize the process of implementation, Regional coordination bodies need to be formed for South Asia, i.e. **South Asia Forum** at the Government level, at the **Regulator** level, at the **planning body** level, **transmission utility** level, at the **system operator** level and at the **accounts settlement/market operator** level.

- A South Asia Power Portal would be made for information of all South Asian countries. This would be maintained by the South Asia Forum at the planning level.

Objective

- Facilitation of cross border trading of power, while ensuring secure, reliable, economic and efficient operation of the grid.

- Facilitation of the coordinated optimal operation of the South Asian Grid.

- Facilitation of coordinated and optimal maintenance planning of generation and transmission facilities in the South Asian grid.

Structure of the Common Minimum Grid Code for South Asia

- Connection Code,
- Operating Code,
- Scheduling and Despatch Code and
- Administration of the Grid Code.

Connection Code

a)To ensure the safe operation, integrity and reliability of the connected South Asia grid.

b)Any new country getting connected to the South Asia grid shall neither suffer unacceptable effects due to its connectivity nor impose unacceptable effects on the South Asia grid.

c)Any new country seeking connection to the South Asia grid is required to be aware, in advance, of the requirements for connectivity to the South Asian grid and also the standards and conditions its system has to meet for being integrated into the grid.

Connection Code

- Require to apply for Connectivity to SAFTU.
- SAFTU will carry out system studies and state whether any augmentation in the transmission system is required.
- Must have provision to implement generation and/or load control mechanisms to be able to control cross border power flows.
- Must abide by the Regional under frequency load shedding schemes to ensure commensurate load shedding
- Must abide by the Regional islanding schemes and system protection schemes, which would be decided by the South Asian Forum of Planning bodies, which are involved in operation planning.

Connection Code

- Must ensure installation of Data Acquisition System, disturbance recorders and sequence-of-events recorder at the interconnection points and other significant points.

- Must ensure robust, redundant and reliable communication between countries, so that voice and data communication takes place instantly and seamlessly across countries.This would be mutually decided by the points of contacts of the South Asian countries.

- Every connection of a country's system to the South Asian grid shall be covered by a Connection Agreement between the SAFTU and the national transmission utility of the country seeking connection.

Operating Code

- Frequency Band - 49.9 –50.05 Hz
- Voltage Band for 400 kV at interconnection point - 380-420 kV

- System Security - Protection Coordination & periodic Protection testing
- Operation liaison.
- Restoration Plans including Black Start.
- Periodic Reports – Daily, Monthly Reports.
- Outage Planning.

Scheduling and Despatch

- Each country to regulate their generation and/or consumers' load so as to maintain their actual drawal from the South Asia grid close to the above schedule.
- Penalty for violations in accordance with a Deviation Settlement mechanism.
- Reactive power drawals to be controlled at inter-country connection points.
- Scheduling and Despatch Procedure.

Administration of the Grid

- Committee for Review of the Grid Code.
- Ultimately, the Forum of South Asia Regulators would do that.

Common Minimum Grid Code (CMGC): Progress

SARI/EI Drafted CMGC and shared with all Regulators & stakeholders of SA countries

Conducted Stakeholder Consultation in Bangladesh, Bhutan, Nepal

Presented CMGC in the 2nd meeting of SAFIR Working Group (Dhaka, 4th Dec,2020)

& in the 18th ECM Meeting (5th December 2019)

18th ECM recommended that each member country may form a Grid Code Review Committee consisting of all the stakeholders to discuss various features of the draft CMGC

SARI/EI/IRADe were requested to do more detailed and comprehensive consultation with the grid code review committee of each country as well as with all stakeholders (utilities, system operators, planners, regulators and policy makers etc.)

Next Step

→ First Consultation with grid code review committees

→ More Detailed Consultation with utilities, system operators, planners, regulators and policy makers etc

→ Second Consultation with grid code review committees and Finalisation of Draft

→ Submission of Revised CMGC to the Chairperson of Regulatory Commissions of SA Countries

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Thank You

Draft

Common Minimum Grid Code for South Asia

PREAMBLE

The Common Minimum Grid Code for South Asia lays down the rules, guidelines and standards to be followed by various South Asia country participants in the system for cross border trading in electricity, while operating the power system, in the most secure, reliable, economic and efficient manner.

1. Short title, extent and commencement

(1) These Regulations may be called Common Minimum Grid Code for South Asia Regulations, 2020.

(2) These Regulations shall come into force from . .2020.

2. Definitions

3. General

a) This Common Minimum Grid Code for South Asia is applicable to all countries of South Asia, who get connected to the South Asia grid through a ***synchronous*** or ***a-synchronous*** (i.e. HVDC) connection.

b) Each country will initially be represented by a single point of contact for the initiation of implementation of the Common Minimum Grid Code.

c) The single point of contact will be supported by the relevant Ministry dealing with power, the Regulator of the respective country, the transmission agency of the respective country, the system operator of the respective country and the accounts settlement/market operator of the respective country.

d) Later, to formalize the process of implementation, Regional coordination bodies need to be formed for South Asia, i.e. South Asia Forum at the Government level, at the Regulator level, at the planning body level, transmission utility level, at the system operator level and at the accounts settlement/market operator level.

e) Till these are formed, the concerned Indian entity can do the coordination in lieu of the respective forums.

f) A South Asia Power Portal would be made for information of all South Asian countries. This would be maintained by the South Asia Forum at the planning level.

4. Objective and Structure of the Common Minimum Grid Code for South Asia

The objective of the South Asia Common Minimum Grid Code is as given below :

(a) Facilitation of cross border trading of power, while ensuring secure, reliable, economic and efficient operation of the grid.

(b) Facilitation of the coordinated optimal operation of the South Asian Grid.

(c) Facilitation of coordinated and optimal maintenance planning of generation and transmission facilities in the South Asian grid.

The structure of the Common Minimum Grid Code for South Asia consists of the Connection Code, Operating Code, Scheduling and Despatch Code and Administration of the Grid Code.

5. CONNECTION CODE

5.1 Objective

The objective of the connection code is as given below:

a) To ensure the safe operation, integrity and reliability of the connected South Asia grid.

c) Any new country getting connected to the South Asia grid shall neither suffer unacceptable effects due to its connectivity nor impose unacceptable effects on the South Asia grid.

d) Any new country seeking connection to the South Asia grid is required to be aware, in advance, of the requirements for connectivity to the South Asian grid and also the standards and conditions its system has to meet for being integrated into the grid.

5.2 Procedure for Inter Country connection

A new country seeking to establish a synchronous connection to the South Asian grid, shall submit an application, on a predetermined format, to the South Asia Forum of transmission utilities (SAFTU). After the study, the SAFTU shall lay down the minimum requirements of additional transmission infrastructure/modifications in the transmission infrastructure necessary to integrate the new country into the South Asian grid.

5.3 Important Technical Requirements for Connectivity to the Grid

a) The SAFTU shall give the minimum requirements of additional transmission infrastructure/modifications in the transmission infrastructure necessary to integrate the new country into the South Asian grid.

A. For a synchronous connection, the following technical requirements hold :

b) This may require the necessity of installing fault current limiters to limit the short circuit current flowing into the country due to connection with a large grid. It may also require reactive power controller in the form of Static Var Compensator/STATCOM, etc. to prevent burdening of the South Asia grid with reactive power drawl/injection beyond certain specified limits.

c) The new country would have to implement generation and/or load control mechanisms to be able to control cross border power flows, in case of contingencies.

d) The new country would also have to abide by the Regional under frequency load shedding schemes to ensure commensurate load shedding in case of grid disturbances to prevent falling frequency, and also abide by the Regional islanding schemes and system protection schemes, which would be decided by the South Asian Forum of Planning bodies, which are involved in operation planning.

e) It would also have to ensure installation of Data Acquisition System, disturbance recorders and sequence-of-events recorder at the interconnection points and other significant points, as specified by SAFTU, to analyse faults through post mortem, so that such instances do not recur.

f) The new country would have to ensure robust, redundant and reliable communication between countries, so that voice and data communication takes place instantly and seamlessly across countries. This would be mutually decided

by the points of contacts of the South Asian countries. The associated communication system to facilitate data flow up to appropriate data collection point at the interface sub-station, shall also be established by the concerned country system operators as specified by the SAFTU in the Connection Agreement.

B. For an asynchronous (HVDC) connection, the following technical requirements hold :

The provisions 5,3 (b), (c) & (d) will not apply.

5.4 Connection Agreement

Every connection of a country's system to the South Asian grid shall be covered by a Connection Agreement between the SAFTU and the national transmission utility of the country seeking connection. The connection agreement shall contain general and specific technical conditions, applicable to that connection, including, but not limited to, the necessary equipment to be installed, the condition of coordination between the System Operators of the South Asian countries, protection coordination, system protection schemes, communication requirements, etc.

6. OPERATING CODE:

A. For a synchronous connection, the following requirements of Operating Code hold :

6.1 Frequency band

All country system operators shall take all possible measures to ensure that the grid frequency always remains within the 49.9 –50.05 Hz band and as revised by the South Asia Forum of Electricity Regulators.

6.2 Grid Voltage

All country system operators shall take all possible measures to ensure that the grid voltage always remains within the following operating range at the interconnection point.

Voltage – (kV rms)		
Nominal	**Maximum**	**Minimum**
765	800	728
400	420	380
220	245	198
132	145	122
110	121	99
66	72	60
33	36	30

6.3 System Security Aspects

Protection coordination would have to be done on a South Asian Regional basis to ensure that the protection schemes are sensitive and selective. Testing of protection devices would have to be done periodically. Protection coordination would have to be done whenever a new major power system element is introduced in the synchronously connected South Asian Grid.

6.4 Operation liaison

Any tripping, whether manual or automatic, of any of the significant elements of country grid shall be precisely intimated by the concerned country system operator to the concerned System Operators, whose grid is likely to be affected, as soon as possible, say within ten minutes of the event. The reason (to the extent determined) and the likely time of restoration shall also be intimated.

6.5 Restoration plan to be done in coordination in case of tripping

All connected countries would have to furnish the required data to the concerned country System Operators whose grid is likely to be affected, and South Asia Forum of planning bodies from disturbance recorders and sequence-of-events recorder within 48 hours of the tripping. Restoration procedures, including black start would have to be laid out by the South Asia Forum of planning bodies for the South Asian Grid as a whole, to facilitate quick restoration of the system after tripping.

6.6 Periodic reports

a) A daily report covering the performance of the regional grid shall be prepared by each country's system operator, based on the format decided by the South Asia Forum of planning bodies, and shall be put on its website. This report shall also cover generation by renewable energy sources, including the quantum of energy injected into grid.

b) A Monthly report covering performance of the national/integrated grid in previous week shall be prepared by the South Asia Forum of planning bodies. Such weekly report shall be available on the website of the South Asia Power Portal for at least 12 months.

The monthly reports shall contain the following:-

(a) Frequency profile

(b) Voltage profile of important substations and sub-stations normally having low /high voltages

(c) Major Generation and Transmission Outages

(d) Transmission Constraints

B. For an asynchronous (HVDC) connection, the following technical requirements hold :

For HVDC connection, the provisions 6.1, 6.2, 6.3 will not apply.

6.7 Outage Planning

Regional outage planning shall be done by the South Asia Forum of planning bodies to ensure that all countries can reap the benefit of optimal utilization of generation and transmission sources, and thus reduce the requirement of each country's reserves.

7. SCHEDULING AND DISPATCH CODE

7.1 The system of each country shall be treated and operated as a notional control area. The algebraic summation of scheduled drawal by the country from all generation procurement contracts through a long – term access, medium -term and short –term open access arrangements shall provide the drawal schedule of each country, and this shall be determined in advance on day-ahead basis.

7.2 The system operator of each country shall regulate their generation and/or consumers' load so as to maintain their actual drawal from the South Asia grid close to the above schedule. If regional entities deviate from the drawal schedule, such deviations from net drawal schedule shall be priced through a pre-decided Unscheduled Interchange (UI) mechanism. Till the time a mechanism for UI is mutually decided at the level of single point of contact of the South Asian countries, the Deviation Settlement mechanism of the largest country in South Asia shall prevail.

7.3 The respective country transmission system operator shall install special energy meters, as specified by the South Asia Forum of Electricity Regulators, on all inter connections between the country grids and other identified points for recording of actual net MWh interchanges and MVArh drawals. All countries shall take weekly meter readings from Monday to Sunday and transmit them to the South Asia forum of accounts settlement operator/market operator by Tuesday noon. The South Asia forum of accounts settlement operator/market operator shall be responsible for computation of actual net injection / drawal of concerned regional entities, 15 minute-wise, based on the above meter readings on a weekly basis by each Thursday noon for the seven-day period ending on the previous Sunday mid-night, in order to prepare and issue the Deviation Settlement account in accordance with the South Asia Deviation Settlement Mechanism, as amended form time to time. All computations carried out by South Asia forum of accounts settlement operator/market operatorshall be open to all South Asia country entities for checking/verifications for a period of 15 days. In case any mistake/omission is detected, the South Asia forum of accounts settlement operator/market operator shall forthwith make a complete check and rectify the same.

7.4 Scheduling and Despatch procedure for long-term access, Medium – term and short-term open access:

a) The country system operators shall advise the South Asia System Operator by 3 PM their drawal/injection schedule for the country as a whole, which would include long-term, medium-term and short-term contracts.

b) **Scheduling of collective transaction**:

NLDC shall indicate to Power Exchange(s), the list of interfaces/control areas/regional transmission systems on which unconstrained flows are required to be advised by the Power Exchange(s) to the NLDC.

Power Exchange(s) shall furnish the interchange on the boundaries of various countries, as intimated by NLDC. Power Exchange(s) shall also furnish the information of total drawal and injection in each of the countries. Based on the information furnished by the Power Exchanges, NLDC (National Load Despatch Centre), the National System Operator of India, dealing with the subject, shall check for congestion. In case of congestion, NLDC shall inform the Exchanges about the period of congestion and the available limit for scheduling of collective transaction on respective country interfaces during the period of congestion for Scheduling of Collective Transaction through the respective Power Exchange. The limit for scheduling of collective transaction for respective Power Exchange shall be worked out in accordance with CERC (Central Electricity Regulatory Commission, the Central Electricity Regulator of India) directives. Based on the application for scheduling of Collective Transaction submitted by the Power Exchange(s), NLDC shall send the details (Scheduling Request of Collective Transaction) to different country system operators for final checking and incorporating them in their schedules.

After getting confirmation from the country system operators, NLDC shall convey the acceptance of scheduling of collective transaction to Power Exchange(s). The country system operators shall schedule the Collective Transaction at the respective periphery of the respective countries.

The individual transactions for the country's intra-country Entities shall be scheduled by the respective country system operators. Power Exchange(s) shall send the detailed break up of each point of injection and each point of drawal within the country to the respective country system operators, after receipt of acceptance from NLDC. Power Exchange(s) shall ensure necessary coordination with country system operators for scheduling of the transactions.

Timeline for above activities will be as per detailed procedure for Scheduling of Collective Transaction issued in accordance with CERC (Open access in inter-state transmission) Regulations,2008 and as amended from time to time.

b) By 6 PM each day, the South Asia System Operator shall convey the despatch schedule to each of the country system operators, in MW for different time block, for the next day, consisting of both bilateral and collective transactions.

c) The country system operators shall inform any modifications/changes to be made in drawal/injection schedule, if any, to South Asia System Operator by 10 PM.

8. ADMINISTRATION OF THE GRID CODE

a) Initially, the Committee of the single points of contact for each country would be responsible for administration and modification of the Common Minimum Grid Code for South Asia. Later this would be replaced by the South Asia Forum of Electricity Regulators.

b) The Committee may meet at regular intervals or as needed for the purpose of administration and modification of the Common Minimum Grid Code for South Asia.

Common Minimum Grid Code for South Asia

Explanatory Memorandum

1. All countries in South Asia have their own Grid Codes, which are generally in order, for their own countries. They contain broad Chapters on Roles and Responsibilities of various concerned organizations, Planning Code, Connection Code, Operation Code including System Security aspects, Scheduling and Despatch Code, Management of Grid Code, etc.

2. Presently, the countries of South Asia, barring Bhutan, are either connected through HVDC links or through radial means. When connected in these ways, the grids of the countries effectively operate independently. In the HVDC form of connection, the grids on either side of the connection can operate at different grid frequencies, the disturbance on one side does not get carried over to the other side, etc. Taking into account the initiatives of the Government of India towards promoting cross border electricity trade, through the Ministry of Power revised Guidelines dated 18.12.2018, and further the transmission plans for cross border lines between countries of South Asia, it is expected that the grids of the countries of South Asia would eventually get connected in synchronous mode, barring Sri Lanka. CERC has issued the CERC (Cross Border Trade of Electricity) Regulations, 2019 on 8.3.2019. After discussions with Chairperson, CERC, it was thought that a Common Minimum Grid Code for South Asia should be formulated to facilitate cross border trade in electricity in ***synchronous*** mode as well as ***asynchronous (HVDC)*** mode of connection.

3. We are therefore proposing a Common Minimum Grid Code for South Asia, with bare minimum changes required in the country's own rules of operation, while ensuring compatibility and grid security, both for ***synchronous*** mode as well as ***asynchronous (HVDC)*** mode of connection. The idea of having a Common Minimum Grid Code for South Asia is to ensure cross border power trade can take place through safe and secure grid operation. The draft Common Minimum Grid Code for South Asia is attached for comments of the South Asian Governments. This will also be discussed in meetings of the Task Forces or otherwise, under the SARI/EI program. The Chapters of the draft Common Minimum Grid Code for South Asia are discussed below.

4. The **Planning Code** deals with transmission planning, in accordance with demand forecast, location of demand and generation sources, considering a certain redundancy criteria, which may be different from country to country. It would be a time taking task for each country to set up transmission lines quickly, if the redundancy criteria are different across countries. Therefore, each country can continue with its planning criteria, to the extent that it does not adversely affect the other country/countries it is getting connected to. If the

redundancy in a country is less than the n-1 reliability criteria, then tripping of a line within the country may cause major changes in cross border flows, if the tripping causes a major load generation imbalance. In such a case, the cross border flow fluctuations can be prevented by putting in place appropriate system protection schemes. Therefore, the Planning Code has been left out in the Common Minimum Grid Code for South Asia.

5. The **Connection Code** is to ensure that any entity which gets connected to the grid has to ensure certain standards of equipment getting connected to the grid, abide with insulation coordination and protection coordination by the transmission planning body of the country and compliance with instructions of the country's system operator or load dispatch centre. In order to operationalize cross border trading of electricity, changing the equipment throughout the country to comply with another country's standards will be time taking and expensive. Therefore, the minimum changes that need to be followed, is change in protection settings in order to ensure protection coordination, so that if a generating unit in a country trips, the country's system operator must ensure that commensurate load is also tripped before another country's load trips. The under frequency and df/dt relay settings need to be coordinated across countries. In case of frequency instability, which generators need to control, the frequency control needs to be decided upfront, through Automatic Generation Control. Alternatively, this can be done through load control. In any case, this needs to be coordinated across countries.

   It is also seen that the Indian grid has got a high fault level, being a very large grid, whereas the other South Asian countries have much smaller grids and therefore low fault levels. If the smaller countries interconnect, there could be large fault currents that could flow to the smaller countries, which could damage their equipment. One way out of this is to install fault current limiters at the boundary sub-station in the smaller countries, that would limit the fault current flowing to these countries.

   The other requirement under connection code would be that the communication system across countries has to be very robust, redundant and reliable, so that instant voice and data communication takes place seamlessly across countries. This is very important for communicating events that have happened and restoration during contingencies/grid events/grid disturbances. All interconnection points must have disturbance recorders and sequence of events recorders to record disturbances, for post mortem of these events/disturbances, to prevent recurrence. In fact, it is a good idea to have these disturbance recorders and sequence of events recorders at all the major generating stations and sub-stations at the higher voltage network in each country, since the tripping could originate from any generating station, line or sub-station in the country.

6. The objective of the **Operating Code** is to enhance the overall operational reliability and economy of the entire electric power network in the country and states how the power system elements connected to the grid are to be operated from the grid reliability and

economy point of view, including the flow of information in normal and abnormal circumstances and the method of restoration from a grid event or grid disturbance. It also gives the frequency limits and voltage limits of operation. These limits may be different across the South Asian countries in their own country grid codes.

The frequency of operation in a synchronous grid is the same at all points in the grid and hence, common limits will have to be prescribed for all countries in the Common Minimum Grid Code for synchronous operation. All countries in this case would be jointly responsible for maintaining the frequency of the grid. Each country in this case has to maintain load generation balance at each point of time barring contingency situations, where power would flow automatically across the countries' boundaries to help prevent a blackout in the country, where there has been tripping of generation. But the situation would have to be normalized quickly in the country of disturbance. For asynchronous operation, some of these conditions are not so onerous.

The voltage is different at different points in the country's grid, depending on reactive loads, voltage drop across lines due to active and reactive power flows, etc. Each country has specified voltage limits at different voltage levels in the country's grid code. This need not be changed. However, for synchronous operation, the only voltage/reactive power drawal/injection that has to be ensured is at the interconnection point between countries. This can be done through installation of static var compensators at the interconnection point, if required.

Another thing that needs to be planned is coordinated outage planning. If all South Asian countries plan to take out their generating units and transmission lines/sub-stations for routine maintenance in a coordinated way, then all countries can reap the benefit of optimal utilization of generation and transmission sources. Restoration procedures would also have to be developed in a coordinated way. For this, and, in fact, for all other codes mentioned above, there have to be regional forums created with representation from all South Asian countries, that are operating in synchronism. The appropriate Regional body would also need to maintain a South Asia power portal for information of the South Asia Region.

7. The **Scheduling and Despatch Code** sets out the procedure of scheduling and dispatch along with timelines. In order to ensure power flows in a methodical way across borders for cross border electricity trade, the scheduling interval would have to be uniform across countries. That is, if India schedules in 15 minute intervals, and Bangladesh schedules on an hourly basis, then that would not enable power to flow. However, if the country Grid Code gives schedules on hourly intervals, they need not switch immediately to 15-minute scheduling. They can give the same value for 4 15-minute blocks in the inter-country schedule. However, it would always be more accurate in future for all countries to switch to 15-minute scheduling. In fact, India is proposing to switch to 5-minute scheduling in

future. The interface meters would accordingly have to have the feature of 15-minute recording.

As mentioned earlier, regional bodies would have to exist in future through association of system operators, association of transmission utilities, association of regulators, association of accounts settlement/market operator, association of planning bodies, and even an association at the bureaucratic and minister level for smooth functioning of cross border electricity trade.

Annexure - II

ACCELERATE SOUTH ASIA POWER MARKET (ASAP): GAP ANALYSIS AND TASKS AHEAD

INTRODUCTION

The World Bank supported South Asia Power Secretaries Round Table (PSRT) has encouraged the World Bank to provide technical assistance to facilitate the creation of a regional electricity/power market, progressing beyond already established bilateral connectivity and bulk power trading to tri- and multi-country arrangements. Within the ambit of this goal, a subgroup of national electricity regulatory entities from Bangladesh, Bhutan, India, Nepal and Sri Lanka (BBINS) have established a Joint Working Group (JWG). JWG is established within the South Asia Forum of Infrastructure Regulation[1] to develop the actions needed to align the regulations (and capacity) of each country to progress to a secure and transparent sub-regional power market. The SAFIR JWG has asked the World Bank to provide technical assistance and analysis for the design of a regional electricity market ("market study"). In parallel, the JWG has asked USAID, under its South Asia Regional Integration (SARI)/IRADe program, to support technical assistance and analysis in grid code and system operations required for a regional electricity market ("grid code study").

This is a discussion note which can be used to facilitate a shared understanding among JWG members, WB and SARI/IRADe on (a) the objectives of the assignment; (b) scope of work and schedule. The scope of work and schedule are subject to change based on terms of financing sources, COVID-19 impacts, and agreement of relevant counterparts to engage.

OBJECTIVES OF MARKET STUDY

JWG's Market Study is intended to meet the following two objectives:

Objective 1. Support member countries through advice and analysis to align regulatory frameworks with a view to increasing bilateral and tripartite CBET between Bangladesh, Bhutan, India, Nepal and (when connected) Sri Lanka, *inter alia* by facilitating – on competitive terms - investment in transmission and generation infrastructure needed for CBET. Such investment may in turn also require suitably structured Power Purchase Agreements (PPAs) and Transmission Service Agreements (TSAs). These issues will need to be addressed through a summary of the work that has already been done in individual countries including the work done by IRADe and dialogue on bilateral and multilateral trade giving due consideration to risk allocation, mitigation of risks, and contracting terms, etc.

Objective 2. Support introduction of regulatory and other measures as early as possible to start participation of Bangladesh, Bhutan, India, Nepal and (when connected) Sri Lanka in regional wholesale

[1] SAFIR which was established in 1999.

trading (Term, DAM, G-DAM, RTM, Ancillary) through a power exchange. This would require *inter alia* (i) a multi-options study on wholesale market design to achieve short run cost optimization (while also enabling an assessment of tradeoffs between short run cost optimization and energy security); (ii) assessment of needs for strengthening institutional and regulatory arrangements; (iii) options for rolling out of measures in stages (short term, medium term); and best practices that can be leveraged to kick start the process quickly.

RATIONALE

Objective 1 – Support member countries interested in increasing investment in additional generation and transmission for the BBIN+S subregional electricity market through gradual alignment of regulatory frameworks that would facilitate bilateral and tripartite CBET between Bangladesh, Bhutan, India, Nepal and (when connected) Sri Lanka through short-, medium- and long-term Power Purchase Agreements (PPAs) and cross border transmission lines.

- Substantial progress in Objective 1 could be achieved over 1 year.
- Key question to JWG members is whether the current regulatory frameworks can support expansion of bilateral and trilateral CBET through PPAs and TSAs, which are critical for new investment. As a prelude to this discussion, it will be important to understand the nature of long-term contracts for generation (and to some extent associated transmission) for each country. The market design for short term power procurement based on the regulatory policy framework in each country shall derive different strategies for optimization of short-term power procurement. This requires a country-specific plan and the work will build on the exercise already done by IRADe. Once the country-specific situation is assessed, the next key question is: *can regulatory revisions reduce risk to investment (debt, equity, etc.), thereby lowering financing costs?* More specifically:
    - *Is there room for a larger participation of these and other players to support win-win scaling up of CBET, with a wider range of generation (especially, investment in renewables from the private sector) and/or transmission developers to expand debt financing and thereby bring cost of financing down?*
    - *Is there a prioritized sequencing of policy, legal and regulatory adjustments that can also take into account each country's evolving views on energy security and inter-dependence?*
- The World Bank has engaged consultants to undertake due diligence on the prevailing legal and regulatory framework in each BBINS country vis-à-vis CBET. A summary of emerging high-level findings, for discussion, are in the **Annexure.**
- WB proposes to engage each JWG member on findings, identify areas for potential adjustments within each country's regulatory framework, and identify areas where coordinated actions are necessary to align frameworks. The latter could be discussed at the JWG after bilateral discussions.

Objective 2 – Leverage CBET for short run electricity cost optimization. Support member countries by informing their deliberations on options for introducing regulatory and other measures as early as possible to start phased participation of Bangladesh, Bhutan, India, Nepal and (when connected) Sri Lanka in regional wholesale trading (Term, DAM, G-DAM, RTM, Ancillary) through a power exchange.

- The outlook on progress in Objective 2 short- to medium-term.

- The JWG will need to work on a detailed design, associated rules and transition mechanisms keeping these in line with the market developments in India.
- Which market product(s) will be the starting entry point will need to be chosen, and under what conditions member countries would be ready to participate will need to be defined. Pros and cons to put efforts into joining existing power exchanges or creating a separate power pool will inform decision on sequencing.
- The feasibility of aligning institutional frameworks and building capacity in time to meet each country's objectives will be a factor in decisions.
- While they can help capture more benefits from trade, internal market reforms are not a prerequisite for participation in power exchanges, but knowledge sharing and capacity building will be needed. Lessons from India's decade-long experience in preparing for, starting and developing its market can help shorten the readiness period of other member states. These lessons will be complemented with experience and lessons from more mature power exchanges. For example:
    - Grid synchronization of Bangladesh with already synchronized India-Bhutan-Nepal would influence market design options and lower costs of transmission.
    - Reforming national dispatching practices could enhance benefits of trade and build capacity. In recent years, India saved millions of USD with Security-Constrained Economic Dispatch (SCED). Short-term dispatch optimization process compliant with the regulatory framework for each country could be considered by other member states.[2] If entry into the power exchange market is expected to take more than one year, implementing SCED within one year for individual countries could be a win-win interim option that saves costs and builds readiness for trade on power exchanges. SCED would build capacity to develop buy/sell offers that are more aligned with optimized national dispatches – this would substantially enhance benefits of trade.[3] Further description of SCED is in the Annexure.

[2] Firstly, the existing planning and dispatch mechanism in the national load dispatch centers of BBNS will need to be reviewed to see how short-term dispatch optimization can be accommodated, if it is already not in place. This is commonplace in markets wherein the market clearing engines fully integrated into SCADA system takes care of such optimization (e.g., PJM real-time engine, European markets, Scheduling Dispatch Pricing software in New Zealand, NEMDE in Australia, etc). In a non-market setting, dispatch engines are also used by the NLDCs, e.g., the South Korean and many of the Central/South American countries and SCED in India. There may be good least-cost dispatch optimization tools already in place integrated into the SCADA system for real-time dispatch. If not, SCED is one of the viable options especially given that it has been successfully deployed by POSOCO in India for more than a year. It is entirely possible that there are other (online) short-term dispatch optimization procedure that is already in place or one of the off-line process being used for scheduling can be more easily integrated in the online SCADA environment. All possible alternatives of effective and efficient short-term power procurement should be given consideration.

[3] The capacity building task would focus on optimization of dispatch in national load dispatch (NLDC) centers akin to what NLDC and regional LDCs (RLDC) in India perform currently. Once the dispatch is properly optimized, the **economic** export/import opportunities can be accurately estimated.

TASKS FOR MARKET STUDY

Component 1. Support member countries through advice and analysis to align of regulatory frameworks to increase bilateral and tripartite CBET between Bangladesh, Bhutan, India, Nepal and (when connected) Sri Lanka, *inter alia* by facilitating – on competitive terms - investment in transmission and generation infrastructure needed for CBET and via medium and long term PPAs.

1. **Due diligence of cross border legal and regulatory frameworks of Bhutan, Bangladesh, India, Nepal and Sri Lanka**.
    a. Review the cross border legal and regulatory framework with each JWG member to identify options and issues for attention to enhance domestic regulatory frameworks and which require regulatory alignment across borders to address Objective 1. *[Time frame: February 2021 - April 2021]*
    b. Support a JWG meeting to discuss issues where regulatory alignment needs coordination. This meeting will identify feasible actions and other steps required for realization. *[Time for JWG meeting: May 2021]*
    c. Deliverable will be for JWG to identify potential actions to enhance regulatory framework to achieve Objective 1.

Component 2. Support member countries by informing their work on introducing of regulatory and other measures as early as possible to start participation of Bangladesh, Bhutan, India, Nepal and (when connected) Sri Lanka in regional wholesale trading (Term, DAM, G-DAM, RTM, Ancillary) through a power exchange.

1. **Study of Regional Wholesale Market Design Options for CBET** This set of tasks assumes that the JWG will look first at leveraging (participate in) India's power exchanges in one or more market product and this experience will inform discussions on the need to establish a separate entity for a regional power pool.

    i. **Gap analysis of institutional framework and capacity for trading on India's power exchanges for each market segment and development of implementation program.** For each member country, the study will assess scenarios of exchange-based trades in various market segments/products (e.g., DAM) that exist now or are contemplated for each member country. The assessment would simulate expected outcomes/benefits, the minimum changes to institutional framework (operating and market rules) assumed to execute trades securely and efficiently, and options for optimizing the institutional framework that would allow countries to capture more benefits of leveraging the market. The study will include:
        1. reviewing substantial analysis undertaken by IRADe (see Annexure) on pros and cons of design options and institutional frameworks as input to the analysis;
        2. simulating of market design options to establish expected impacts on exchange prices and potentially an impact on the capacity utilization of certain generation assets (e.g., there is some concern that a Unified market would raise prices [for customers in some countries?] even if it provides the optimum benefits regionally). The simulations will enable countries to develop policies to manage these impacts while also benefiting from the optimization potential of a sub-regional wholesale market;

3. assessing institutional frameworks of each country, identify options for minimum changes required to enter each product of the market, and assess practicability of these changes based on detailed consultations with stakeholders and timelines;
4. establishing a roster of national and international experts that will be asked on an as needed basis for consultations on outputs and participate in JWG discussions;
    a. Individual national expert inputs on special topics would be invited as per requirements.
    b. JWG members would be responsible for convening national experts.; and
    c. WB would support hiring of three international market experts from US, Europe and South Africa Power Pool. International experts will be asked to provide their input on the pros and cons of participation in various market design options, identification of risks and mitigation measures based on their experience. The market experts will introduce relevant lessons from development of regional markets in Europe (e.g. NordPool design that forms a single entity), South Africa Power Pool (also, single entity), and the United States (more recent developments like the Western Energy Imbalance Market (EIM) that leverages one key market and coordinates imbalances in real time).
5. present a synthesis report that provides a detailed mapping of options for each country and market product, detailing the rationale for the proposed sequencing, expected benefits and risks, proposed options to address issues requiring policy and regulatory coordination. The study should define options in the short-term and in the medium-term, including considerations of key elements: (i) Decision on compliance for participants, (ii) Bidding zones and ATC calculation process agreed by system operators, (iii) Developing a preliminary view on alignment of cross border trade with ongoing developments in the Indian market including Market Based Economic Dispatch (MBED) and ancillary services market arrangements through a study, and finally (iv) Conduct a study collating different formulations of market clearing algorithms used in the region as well as internationally to develop options for the regional market clearing engine (MCE) ;[4]
6. stakeholder consultations on market design options – after a reasonable draft is prepared that outlines benefits of participation and requirements for participation (institutional framework and capacity needs), a round of stakeholder consultations will be facilitated by the Consultant with the support of the JWG and the Bank. The consultations will solicit views on the practicability of introducing more market trading and options that make sense, as well as other relevant issues;

ii. **Concurrently, if desired, knowledge sharing and capacity building to strengthen institutional capacities for optimizing national dispatches to harness benefits of CBET.** Irrespective of market design, it is important to build capacity in BBINS to develop offers that are more aligned

[4] It is important to clarify that the four tasks noted here may be accomplished in a year or so and these can be initiated concurrently with other activities. Some of the items, especially (i)-(ii) are likely to be in the offing or may even be already settled, while (iii)-(iv) are deeper issues that may be addressed at a high level initially through a study. It is however useful to address these points through a study to look at a broad set of options (e.g., should regional market also consider MBED features and ancillary services) rather than necessarily jumping to a conclusion (e.g., follow the status quo) so that expensive and disruptive rework in future can be avoided.

with optimized national dispatches. This will require collaborative and coordinated capacity building exercise across all five countries. We propose to prepare a study to examine available dispatch optimization alternatives to inform member countries deliberations on the best way forward. This would share lessons and practices of dispatch optimization that would eventually help to ensure national level dispatches are optimized which in turn can help market agencies in NLDCs to develop cross-border trade offers that are in full alignment with optimized national dispatches. This work could be done in a relatively short period of time, especially in Bangladesh and Sri Lanka, estimated to be about 12 months. Since India already has SCED in place, we will mostly work with other countries on this issue, but will also explore enhancements to SCED that may be needed. SCED itself is a viable option and we will explore this first. See Annex for additional details.

2. **Capacity Building Support.** Pending funding availability, a review of previous training (e.g. by IRADe) and need, the study contemplates a need for training and knowledge exchange such as:
    a. Training course on market-oriented economic regulation of transmission which will cover the economic principles, international best practices on market-oriented transmission planning and cost allocation of transmission projects;
    b. Coursework on Security Constrained Economic Dispatch and demonstration of the SCED software developed by POSOCO;
    c. Seminars by market design experts on international electricity markets including the key European, American and Asia Pacific implementations;
    d. Workshop on recent advancements in market clearing engines, specific areas where the regional market clearing process needs to focus, and certification/audit process needed to ensure the MCE is fully tested; and
    e. Workshop on pilot design and protocols.

IMPLEMENTATION SUPPORT

1. **Implementation Support**. Country-executed modalities and financing options will need to be identified for this component, which would need to be defined after the study is completed and JWG/member countries have made choices on market options. Nevertheless, the JWG should not lose sight that implementation will require additional expenditures for activities such as:
    a. **software development and testing**: the MCE specification will need to be implemented either as an extension to the existing engine in IEX/PXIL or as a new engine. The modified/new engine will need to be tested extensively to make sure the clearing of the core market with CBET is done correctly. The engine will need to be certified by an external auditor on compliance of the engine with the market rules
    b. **pilot the market:** the new regional electricity market including participants from BBN(S) will need to be piloted. This is critical in part because there are concerns around CBET increasing prices in India which in turn has ramifications for alternative design that the market may take.[5]

[5]There are some design choices that will need further investigation. For instance, there is a need to examine sequential clearing of Indian market followed by regional which preserves prices in India but

COORDINATION WITH SARI/IRADe

The JWG will benefit from close coordination between the Bank and SARI/IRADe. It is proposed to maintain good coordination with SARI/IRADe to promote sharing of knowledge, complementary activities and ensuring full funding of priorities.

Comment on Operational Grid Code for the region (SARI): The work to date developed a framework and identified many areas where the Grid Codes of the countries will need to be aligned. We also recognize that a Grid Code is a living document that will need to be amended as the generation mix/technology, transmission technology, market conditions, etc., change over time. The Indian Electricity Grid Code (IEGC) itself is 10 years old with four amendments done to it. IEGC as well as the other Grid Codes will evolve - this is a significant piece of work to bring it in line with the international best practice.[6]

It will be important to put in place a working draft of the regional grid code approved by the regulatory bodies. It will need to be done in close coordination with the system operators.

There will be a myriad of issues to address starting with a uniform connection standard for new generators, especially solar and wind projects in the region; dispatch practices, security standard including how protection system settings will be put in place and operated to cover for cross-border interconnectors.

INTERCONNECTOR PLANNING

1. Financing for interconnector planning support is not identified as member countries have not requested this support and specific interconnectors have not been identified. However, member countries should be aware that there is a need for continuous improvement in providing greater clarity in the expected participation in CBET among major consumers in the regional market. This clarity will help to drive timely and efficient investment in cross border transmission interconnectors as well as new clean generation.

2. A broad master plan for possible interconnections had been studied a few years back; however, only a subset of these interconnectors totaling about 6.0 GW of transfer capacity (with the majority connecting Bhutan with India) is currently operational. There is a need to start planning and preparation for additional transfer capacity and the next set of interconnectors should be done by planning bodies, transmission companies and regulators also to implement the transmission grid code and related regulatory principles.

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has lower economic benefits, vis-à-vis uniform clearing that ensures higher benefits of the market at the expense having an impact on prices in India.

[6] For example, the UK National Grid code has gone through more than 40 revisions and runs over 1000 pages, compared to 4 revisions and < 100 pages of the IEGC.

3. It would also be advisable that they follow a sound economic cost-benefit analysis framework used by studies over the last decade to ensure international best practices are reflected.[7]

4. Such **Interconnector Planning through Pre-Feasibility/Multi-Options Studies for Proposed Interconnectors,** includes (a) planning optimization to test the economic and financial merits of the interconnector covering alternative routes, voltage class and grid upgrade requirements and (b) load flow and stability studies at a regional level. If there is an AC link considered (e.g., between Bangladesh and India), the scope of the stability analysis will need to consider the integrated transmission system including impact on frequency in one system under normal conditions (e.g., the integrated system frequency excursions, especially that of Bangladesh, might reduce significantly) as well as following a contingency in the other system (e.g., there is the potential risk in one country cascading into the other system with major frequency drop). In other words, the analysis would effectively look into the benefits as well as costs/risks of synchronizing the two systems. Although the analysis will focus largely on an incumbent project, it will need to consider the broader issues around synchronization, necessary mitigation measures including Special Protection System to prevent cascaded outages.

[7]See for example, the economic cost benefit analysis procedures followed by Californian ISO, Australia and ENTSOE.

ANNEXURE: ADDITIONAL DISCUSSION ON THE TASKS AHEAD

HIGH LEVEL FINDINGS OF CROSS BORDER LEGAL AND REGULATORY FRAMEWORK

Synopsis: Cross-border electricity trade (CBET) among BBIN countries (Bangladesh, Bhutan, India and Nepal) has doubled since commissioning of the first high voltage (HV) transmission lines between Bangladesh-India (2013) and Nepal-India (2016). This more recent CBET has added to steadily expanding Bhutan-India trade and has demonstrated that CBET among these countries is both doable and mutually beneficial. Importantly, this connectivity and trade has grown under existing legal frameworks in each country, facilitated by government-to-government policies/agreements, and accommodative regulatory and contractual arrangements (PPAs/TSAs). An important contributer has been the learnings and capacity generated by India's own experience over the last decade in integrating its national electricity transmission system and expanding its trading mechanisms.

Other than Bhutan-India, where CBET has involved capital-intensive investments in new hydropower plants and long-distance HV lines, development of trade between India, Bangladesh and Nepal has been capital-light (relative to energy traded), with short-distance HV lines to connect existing (underutilized) generation capacity in India with unmet demand (because of generation shortages and/or high cost) in the neighboring countries. Institutional mechanisms for cross-border dialogue and cooperation facilitation, including with support from development partners, have helped manage asymmetries in capacity, resolve potential disputes, and establish a stable foundation for ramping up CBET within BBIN, and extend it to Sri Lanka (which will require the country to amend its legal framework to enable CBET). Public sector entities have dominated this first phase of CBET development, with the private sector beginning to take a visible interest, especially in new generation for a cross-border market.

Building on the above foundations, and on emerging new export-oriented generation projects (India-Bangladesh, Nepal-India-Bangladesh), CBET is poised to expand. Key elements of the next phase are expected to include:

1. A sub-regional **wholesale electricity exchange**, providing an opportunity for countries to optimize short-run generation costs and improve services;
2. New, greenfield **generation** investments, moving beyond CBET based on existing surpluses towards generation increasingly optimized for a cleaner and more competitive sub-regional market, while also expanding the options for each country to manage its energy security;
3. **Tripartite trade**, moving beyond bilateral transactions to including third countries, with the transmission systems of each providing the technical, policy and regulatory arrangements for reliable and cost-effective access;
4. Increase in **cross-border transmission capacity** and grid integration, boosting confidence in cross-border sourcing and sales of electricity; and
5. **Sri Lanka**, extending the emerging BBIN network and CBET benefits to Sri Lanka.

Higher capital investments – needed for scenarios involving new generation and long-distance/complex transmission – will require better harmonized legislation and regulations across countries to attract a

wider range of strategic investors and to drive down risk-adjusted financing costs. Harmonized legislation would seek to create a level playing field – with safeguards for national interest – in areas such as investment security (expropriation, change-in-law), transmission access, and market participation. Overlaying such harmonization with a legally-binding investment-cum-trade treaty between participating countries will further bolster investor confidence.

SECURITY CONSTRAINED ECONOMIC DISPATCH FOR BBNS: RATIONALE

1. Security Constrained Economic Dispatch (SCED) developed and implemented by POSOCO (India)[8], is a mechanism that facilitates least-cost electricity supply based on merit order dispatch for the central sector generating stations (total 58 GW) in India. SCED was introduced in April 2019, i.e., after a decade of market operation, mainly to ensure central sector generators that do not participate in the market, can be dispatched optimally for their share of generation that is not allocated to any state for the day. Taking into account system constraints and spinner reserve requirements, SCED optimizes generation based on variable cost and honors all of existing rules on allocation of generation to states and is accordingly performed around a "scheduled" generation.

   When higher variable cost generators are dispatched less than their scheduled generation, and lower cost generators are dispatched more than their scheduled level – there is a net savings to the system (net of heat rate compensation paid to generators because some generators will be forced to generate at a less efficient level). This savings is collected by the system operator on a 15-minute basis for each dispatch period and split 50:50 between participating generators and DISCOMs at the end of each month. Individual DISCOMs receive their allocation of the savings from this 50% system savings in proportion to their final schedule from the generating stations covered under SCED. The generators benefit (i.e. the other 50% of the net savings accrued in the pool) would be shared between generators who generate more than their schedule (SCED UP) and those who generate less than the schedule (SCED DOWN) generators in the ratio of 60:40 respectively for each 15-minute dispatch period.[9]

   While the SCED implementation in India deals exclusively with central sector plants that do not have PPA, the allocation to states effectively have the same quantity (and price) obligations. The scheme can therefore be applied in other jurisdictions like Bangladesh where there is a mix of plants that are owned by BPDB and IPPs (with PPAs and heat rate performance associated to them). It is important to note that the SCED principles are flexible and can be applied retaining all of the commercial and regulatory constraints including PPAs and (state) quotas and technical issues (namely, heat rate penalties, minimum operating limit, and ramp rate penalties). It is also possible to explore other possibilities wherein cost-benefit of some of these constraints can be assessed and they are reduced/removed over time (e.g., the minimum operating limit as well as low ramp rates in India have been studied extensively as part of SCED analysis).

[8] See the SCED January 2020 Report.
[9] *Ibid* Section 2.1.4, p.27.

2. SCED is meant to primarily bring system cost down. Over April-December 2019, SCED saved INR 8.45 billion ($120 million) over a 9-month period. A second benefit that also resulted from it is a more stable dispatch pattern that essentially keeps the cheaper generator persistently at their maximum available capacity. The dispatch schedule prior to introduction of SCED had been quite arbitrary as it often involved rapid changes to the schedule to manage heat rate penalty and state level quota. A clear focus on system cost through SCED also had this associated benefit of avoiding these by as much as 42% (in MW terms). SCED is complementing the IEX/PXIL markets in India for generators that are locked into state level quotas and hence cannot participate in the market. It is in fact ~10 times the size of the combined IEX and PXIL market volume and have generated significant level of savings and the implementation of the mechanism was relatively quick (~6 months), developed internally by POSOCO and cost-effective.[10] It is also in the process of rolling SCED out to the load dispatch centers of states (SLDC) in India so that they can perform the same optimization for their generators.

3. SCED can be introduced in other countries in two different modes:

    a. A 'national' version independently for each country purely to improve dispatch within their national boundaries, i.e., the way India optimizes the dispatch of its central sector generating units. It is simpler to implement but will not optimize the CBET among the countries; and

    b. A 'regional' version of SCED that optimizes dispatch of generators within a country as well as CBET and thereby provides a sound basis for engaging in trade with neighboring country (i.e., India in this case). Implementation of this version will be more complex as it would require regulatory pre-requisites to be met, the engine to be identical across the countries, data to be exchanged in real-time.

        If the dispatch process followed on the Indian side is fully aligned, for instance around the same SCED, the coordination of dispatch can be made easily to absorb any economic surplus to be exported to India and supplant expensive generation (e.g., HFO in Bangladesh that would otherwise be needed during summer peaks) with cheaper import. The additional benefits from CBET optimization is a plus for this option.

        The dispatch process together with dispatch **coordination** can effectively play the role of a mechanism to realize the gains of trade – very similar to how a cost-based pools in other countries (namely, SIEPAC and US-Canada trade historically) work. It is, however, the 'second best' option because it does not provide an explicit price signal or allow the flexibility for bids and offers by the DISCOMs and generators aligned with their businesses. It is an option that should eventually be superseded by a proper market mechanism as soon as possible and should therefore be seen as an interim option to

[10] less than $200K based on discussions with POSOCO.

build capacity, be acquainted with the concept of trade until the market mechanism is ready.

4. Regardless of the version of SCED employed, it will support market development. SCED will support market development in more than one way, namely:
    a. It yields system marginal prices (SMP) that are akin to prices in a market.[11] SMPs will provide insights into hourly/sub-hourly prices (say 15-minute if the dispatch processes can be set up at the same resolution as India has) including how the system marginal cost varies over the days, weeks, months and seasons. Simulation studies using past demand/dispatch would also be helpful to understand prices. All generators can look at such data to understand how they should be structuring their bids in a market set up to be dispatched and meet their contractual obligations
    b. a transparent dispatch order for all generators to understand the dispatch pattern they should strive for in a fully competitive market (i.e., everyone bidding at their true cost as the least-cost dispatch regime in SCED implies); and

5. the single buyer entities like BPDB and NEA can gain significant insights into the benefits of an optimized dispatch and cross-border power trade (with India) on their cost of purchase.

6. Firstly, the existing planning and dispatch mechanism in the national load dispatch centers of BBNS will need to be reviewed to see if SCED is needed. There may be good least-cost dispatch optimization tools already in place integrated into the SCADA system for real-time dispatch. If not, SCED is one of the viable options especially given that it has been successfully deployed by POSOCO in India for more than a year.

7. BBN system operators already liaise with POSOCO for CBET and building the cross-border transfers into the SCED optimization would be a useful step towards market development. It should be possible to extend the current logic in SCED to optimize part or the full volume of CBET taking into consideration contractual obligations and observing the transfer capability. In other words, the current domain of SCED which covers only central sector plants in India may be extended to cover transfers between India and Bhutan/Nepal/Bangladesh. SCED will also be deployed in these three countries and the two set ups can be directly linked so that (a) dispatch in each of the BBIN countries is optimized; and (b) CBET among these countries are also co-optimized.

8. Although Sri Lanka is not current connected with India, the extent to which SCED helps CEB to perform a real-time dispatch engine fully integrated into its SCADA system would complement the off-line optimization that is being done. It may for example help to manage the variability in wind closer to time and manage spinning reserve.

[11] The SCED report published by POSOCO for example shows how SMPs calculated by SCED align quite well with the IEX prices: see for example pages 67-70 of the POSOCO report referred earlier .