

Brief Report

on

SARI/EI Delegation to Bhutan to meet and discuss with critical stakeholders such as Bhutan Electricity Authority, Bhutan Power Corporation, Bhutan Power System Operator and Department of Hydro Power System, Ministry of Economic Affairs on the SARI/EI Task Force-2 Study on “Harmonization of grid codes, operating procedures and standards to facilitate/promote Cross Border Electricity Trade in the South Asia Region”

6th-7th April, 2016, Thimpu, Bhutan.



SARI/EI Delegation Members

Mr. Rajiv Ratna Panda, Head-Technical, SARI/EI, IRADe

Dr. K. Balaraman, Chief General Manager, PRDC

Mr. Chandra Shekhar Reddy Atla, Manager, PRDC



Background:

There has been an unprecedented growth in electricity demand in South Asian countries in the last decade. All South Asian countries are looking for alternate ways to meet this ever growing demand of electricity as this is the backbone of the economies of South Asian Countries (SAC). In order to bridge the demand, supply gap, Cross Border Electricity Trade (CBET) has emerged as viable and economical option and various steps are being taken in advancing CBET in the South Asian Region (SAR). There are already CBET between India-Bhutan, India-Nepal, India-Bangladesh. These CBET trades are bi-lateral and limited in transaction vis-a-vis the huge CBET potential that exists in the SAR. A full-fledged CBET trading requires an integrated regional electricity grid and there are various technical, operational, regulatory challenges of integrated regional electricity grid in South Asia. Operating an integrated electricity grid in South Asia is essentially a technical, operational and coordination issue and there is a need for harmonizing/coordination of the technical rules, standards, grid codes and operating procedures. Harmonization means adjustment of differences & inconsistencies among measurements, methods, procedures, schedules, specifications, or systems to make them uniform or mutually compatible.

In this context, SARI/EI under Task Force-2 have commissioned a study on “Harmonization of grid codes, operating procedures and standards facilitate/promote cross border electricity trade in the south Asia region”. As a part of this study, the harmonization of grid codes for South Asian region follows a three stage approach. In the first stage, the comparison of grid code of South Asian region and gaps was identified from the perspective of facilitating CBET. In the second stage, the international grid codes pertaining to cross-border transactions are analysed, impact analysis is carried out and significant inference for SAC were drawn. In the third stage, based on the findings of stage 1 & 2 and inputs/suggestion received from TF-2 members, the draft framework guideline on integrated regional Planning, Operation, Connection, Metering, Capacity allocation & Congestion management and Scheduling & Dispatch were prepared. Draft Framework guidelines are comprehensive in nature and encapsulates: 1) Impact analysis; 2) Explanatory statement; 3) Implementation provisions; and 4) Draft code.

In the above context, it was felt during the combined meeting of SARI/EI task forces and 5th meeting of TF-2 that there is a need for SARI/EI and PRDC (Consultant) to have detailed stakeholder consultation/discussion with key stakeholders of the South Asian Countries in particular with regulators, load dispatch centers and power system planning department who are technical custodian of planning and operation of power system to better understand their operating/dispatch philosophy, relevant regulatory governance and system planning and discuss the draft framework guidelines.

In the above context, SARI/EI/IRADe Delegation comprises of Mr. Rajiv Ratna Panda, Head-Technical, SARI/EI, IRADe, Dr. K. Balaraman, Chief General Manager, PRDC and Mr. Chandra Shekhar Reddy Atla, Manager, PRDC visited Bhutan on 6th-7th April, 2016. The delegation held detailed discussion with critical stakeholders such as Bhutan Electricity Authority (Regulator), Bhutan Power Corporation (Transmission and Distribution Utility), Bhutan Power System Operator (Transmission System Operator) and Department of Hydro Power System, Ministry of Economic Affairs (System Planning and Policy Making).



Meeting and Discussion with Bhutan Electricity Authority (BEA)

SARI/EI/IRADe delegation held detailed discussion with the BEA team on Draft Framework Guidelines on CBET grid codes on 6th April, 2016 at BEA office. Mr. Rajiv from SARI/EI/IRADe initiated the meeting and made a detailed presentation on the study on harmonization of grid codes covering a) scope of the study b) methodology and approach c) importance, context and a brief of the draft framework guidelines. The detailed presentation is attached as Annexure II. Dr. Balaraman from PRDC presented in detail the draft framework guidelines along with draft CBET grid code to the officials. A detailed questionnaire on framework guidelines was also discussed.



During the discussion, the delegation stressed that the draft framework guidelines are not intended for replacing the country grid codes, but deals with limited aspects with respect to CBET. For example all generators which are connected to country's internal transmission network has to follow respective country grid codes, however for generators which are directly connected to cross border lines, they have to follow framework guidelines and CBET grid codes which are non-binding in nature to begin with.

Various suggestions and inputs were made by BEA. The delegation requested BEA for their detailed responses on the questionnaire on draft guidelines on or before 18th April 2016 which will help to discuss inputs of BEA during the TF-2 meeting which is scheduled to be held on 20th April 2016. BEA responded positively to the request of the delegation. The list of officials interacted is attached as Annexure I.



Meeting and Discussion with Bhutan Power Corporation (BPC)

SARI/EI/IRADe delegation held detailed discussion with the BPC team on Draft Framework Guidelines on CBET grid codes on 6th April, 2016 at BPC office. Mr. Rajiv from SARI/EI/IRADe initiated the meeting and made a detailed presentation on the study on harmonization of grid codes covering a) scope of the study b) methodology and approach c) importance, context and a brief of the draft framework guidelines. Dr. Balaraman from PRDC presented in detail the draft framework guidelines along with draft CBET grid code, particularly on planning and operational aspects of the CBET grid code. Various suggestions and inputs



were made by BPC, for example BPC mentioned that consideration of existing 132 KV and 220 KV interconnections between India and Bhutan needs to be considered in the framework guidelines and in CBET grid code as it is limited to the interconnections at 400 KV and 765 KV level only. The delegation requested BPC for their detailed responses on the questionnaire on draft guidelines on or before 18th April 2016 which will help to discuss the inputs of BPC during the TF-2 meeting, which is going to be held on 20th April 2016. BPC responded positively to the request of the delegation. The list of officials interacted is attached as Annexure-III.

Meeting and Discussion with Bhutan Power System Operator (BPSO)

SARI/EI/IRADe delegation held detailed discussion with BPSO team on Draft Framework Guidelines on CBET grid codes on 7th April, 2016 at BPSO office. Mr. Rajiv from SARI/EI/IRADe initiated the meeting and spoke on a) scope of the study b) methodology and approach c) importance, context and brief of the draft framework guidelines. Mr. Ujjwal GM, BPSO presented the present operational procedures, generation forecast, demand forecast and scheduling guidelines etc. of Bhutan. Dr. Balaraman from PRDC presented in detail the draft framework guidelines along with draft CBET grid code, particularly on operation, scheduling & dispatch aspects of the CBET grid code to the BPSO officials.



Some of the key points emerged during the meeting are a) all bilateral CBET transactions are done between BPSO and NLDC-Delhi b) BPSO mentioned that the state estimation is not being used for operation as they are able to manage the system with real time measurements as the system is considerably small c) Tala and Chukka has 4 hours reservoir storage, however the Dhadchu generation station does not have storage d) BPSO mentioned that they are working towards free governing mode for generators e) BPSO raised the concern about the country security in case of major generation outage. Country grid security or CBET transaction should be given priority before islanding the country grid from CBET f) SARI/EI delegation mentioned about the critical importance of cross border lines during grid disturbance and briefed the BPSO officials that the study has recommended special protection schemes in the country to take care of loss of generation and this will help to maintain CBET line flow as it must run status g) BPSO raised the calculation of loss for CBET transaction and SARI/EI delegation briefed the BPSO officials that the study has recommended a cross border fund for loss accounting as detailed in draft guidelines and has suggested the transmission charges shall be based on MW basis and not on energy basis.



Delegation requested BPSO for their detailed responses on the questionnaire on draft framework guidelines on or before 18th April 2016 which will help to discuss inputs of BPSO during the TF-2 meeting which is going to be held on 20th April 2016. BPC responded positively to the request of the delegation. After the meeting Mr. Ujjwal, GM, BPSO explained the functioning and operation of the BPSO load despatch centre and briefed the delegation through the live operation of the load despatch centre. The list of officials interacted is attached as Annexure-IV.

Meeting and Discussion with Mr. Karma Teshwang, Chief Engineer, DHPS, MoEA.

SARI/EI/IRADe delegation held a brief discussion with Mr. Karma Teshwang, Chief Engineer DHPS, MoEA and Task Force -2 Member of SARI/EI on 7th April, 2016 at DHPS, MoEA office. The delegation appraised him about the details of meetings/interaction with BEA, BPC and BPSO. The delegation also briefed him about the status of the study on “Harmonization of grid codes, operating procedures and standards to facilitate/promote cross border electricity trade in the South Asia Region”

.....***.....

Annexure -I: List of officials of BEA participated in the meeting/discussion and interacted with on 6th April,2016

| |
|---|
| 1. Mr. Samdrup K Thinley, CEO, BEA |
| 2. Mr. Nima Tshering C, Chief, Licensing & Technical Division, BEA |
| 3. Mr. Sangay Phuntsho, Senior Legal Officer, Legal Affairs Division, BEA |
| 4. Ms. Thukten Wangmo, Acting Chief, Monitoring Division, BEA |
| 5. Mr. Thinley Zangpo, Deputy Executive Engineer(Electrical), Monitoring Division, BEA |
| 6. Ms. Chandrika Mongar, Deputy Executive Engineer, Licensing & Technical Division, BEA |
| 7. Mr. Jigme Dorji, Monitoring Engineer, Monitoring Division, BEA |
| 8. Mr. Sangay, Monitoring Engineer, Monitoring Division, BEA |
| 9. Mr. Rinchen Dorji, Licensing & Technical Division, BEA |

Annexure -III: List of officials participated in the meeting/discussion with BPC on 6th April,2016

| |
|---|
| 1. Mr. Gem Tshering, MD, BPC |
| 2. Mr. Ujjwal Deep Dahal, GM, BPSO |
| 3. Mr. Kuenzang Dorji, Sr. Manager, BPC |
| 4. Mr. Kuenzang Tobye, Sr. Manager, BPC |
| 5. Mr. Ugyen Tshomo, Sr. Manager, BPC |

Annexure -IV: List of officials participated during the meeting/discussion with BPSO on 7th April, 2016.

| |
|---|
| 1. Mr. Ujjwal Deep Dahal, GM, BPSO |
| 2. Mr. Kuenzang Dorji, Sr. Manager, BPC |
| 3. Mr. Kuenzang Tobye, Sr. Manager, BPC |
| 4. Mr. Ugyen Tshomo, Sr. Manager, BPC |
| 5. Mr. Jigme Dorgi, Engineer, BPSO |
| 6. Mr. Nima Tshering, Engineer, BPSO |
| 7. Mr. Ngawang, Sr. Engineer, BPSO |





USAID
FROM THE AMERICAN PEOPLE



Annexure II :

Presentation

on

SARI/EI Study on Harmonization of grid codes, operating procedures and standards to facilitate/promote cross border electricity trade in the south Asia region:

Draft Framework Guidelines





USAID
FROM THE AMERICAN PEOPLE



Background

South Asia Regional Initiative for Energy Integration (SARI/EI)

● SARI/E is a long standing program of USAID started in the year 2000.

● Program has consistently strived to address energy security in South Asia by focusing

- 1) Cross Border Energy Trade
- 2) Energy Market Formation and
- 3) Regional Clean Energy Development.

● SARI/EI–Phase IV (2012-2017): Key Outcomes.

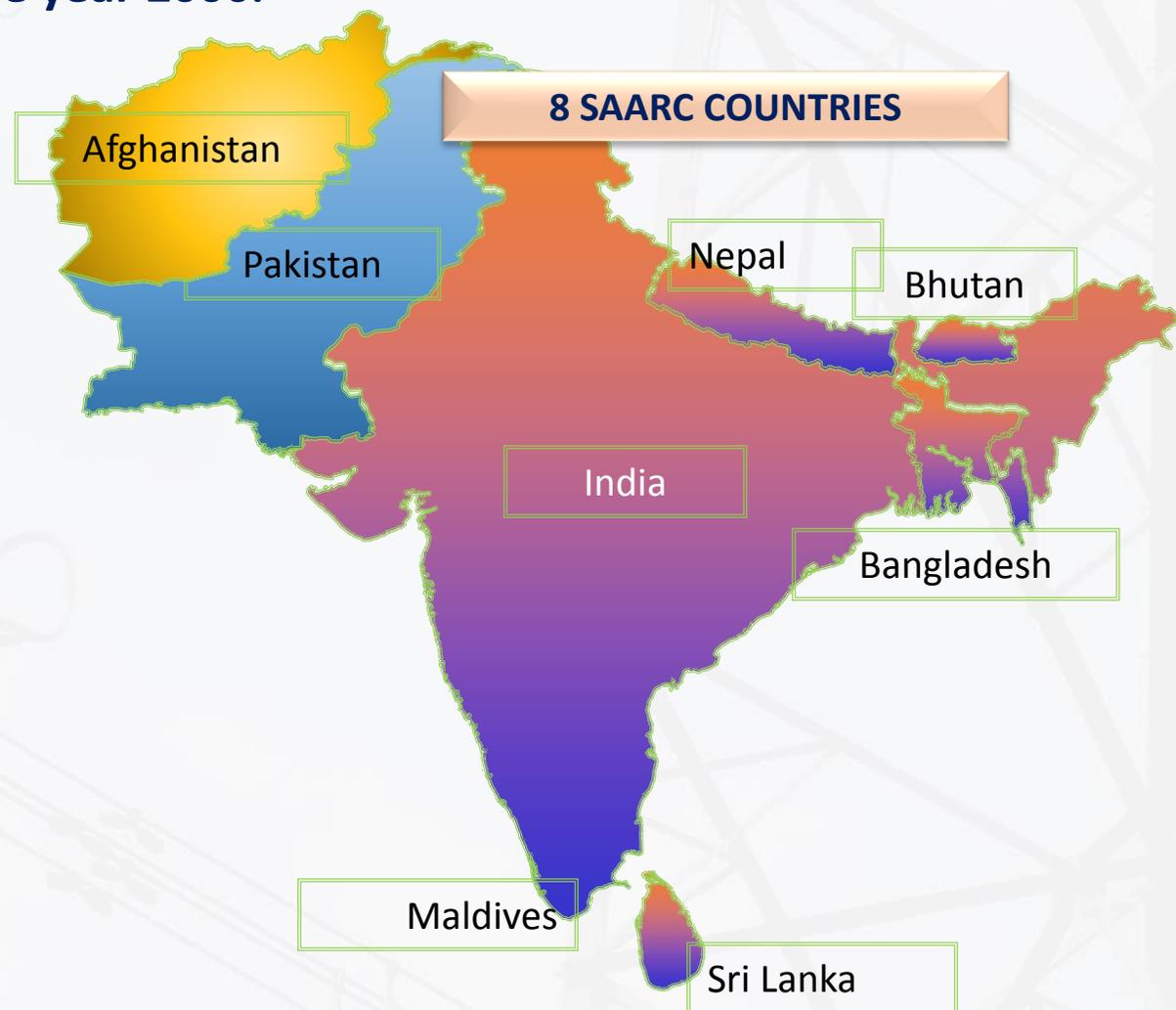
Three Key Development Outcomes:

1. *Coordinate policy, legal and regulatory issues.*
2. *Advance transmission interconnections.*
3. *Establish South Asia Regional Electricity Markets.*

● First Three Year of the Program is Completed.

● Demand Driven ‘Bottom Up’ Approach

● IRADe, a regional organization, is implementing partner

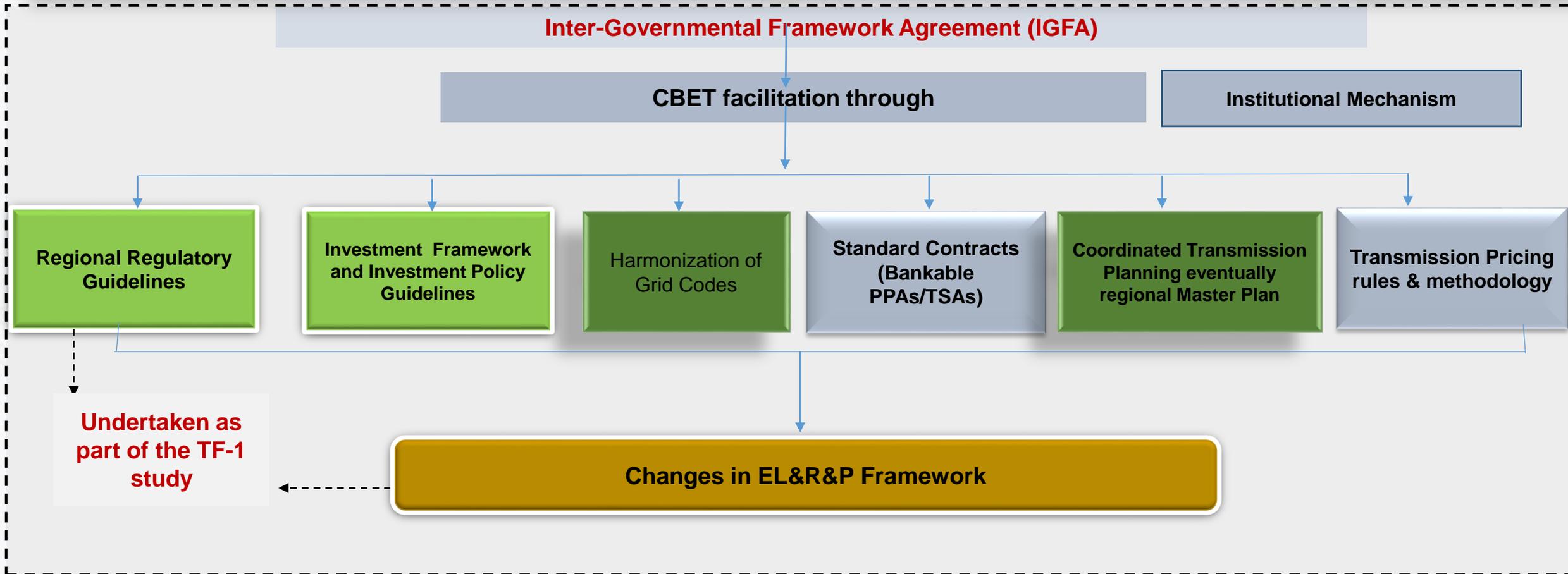


SARI/EI Framework

- **Project Steering Committee (PSC)** is the apex body of the program and provides overall strategic directions.
- PSC members consist of government nominated **Senior level officials from the country governments, SAARC, ADB, Independent Energy Experts/Diplomats.**
- Task Force Members are represented by **government nominated members from Regulatory Technical, market related institution of each SA countries.**



Overall Framework for development of CBET in South Asia



Demand Driven Studies /Exercises to Achieve the Deliverables of Task Forces as Defined in the Terms of Reference of Task Forces



TF-1 :

● **Study -1:** Study on Review of policies, regulations and laws, preparation regulations etc. *(Report has been finalized, Proposed Changes, amendments in electricity laws, regulations and policies Regional Regulatory Guidelines) -Completed*

● **Study-2:** Study on Investment policies/guidelines for SA countries *(bids under evaluation and to be awarded soon)*



TF-2 :

● **Study 1:** Study to find out the Trading Potential of South Asian Countries *(Draft Final Report prepared-Ongoing)*

● **Study 2:** Harmonization of Grid Codes *(Draft Final Report Prepared-Ongoing)*

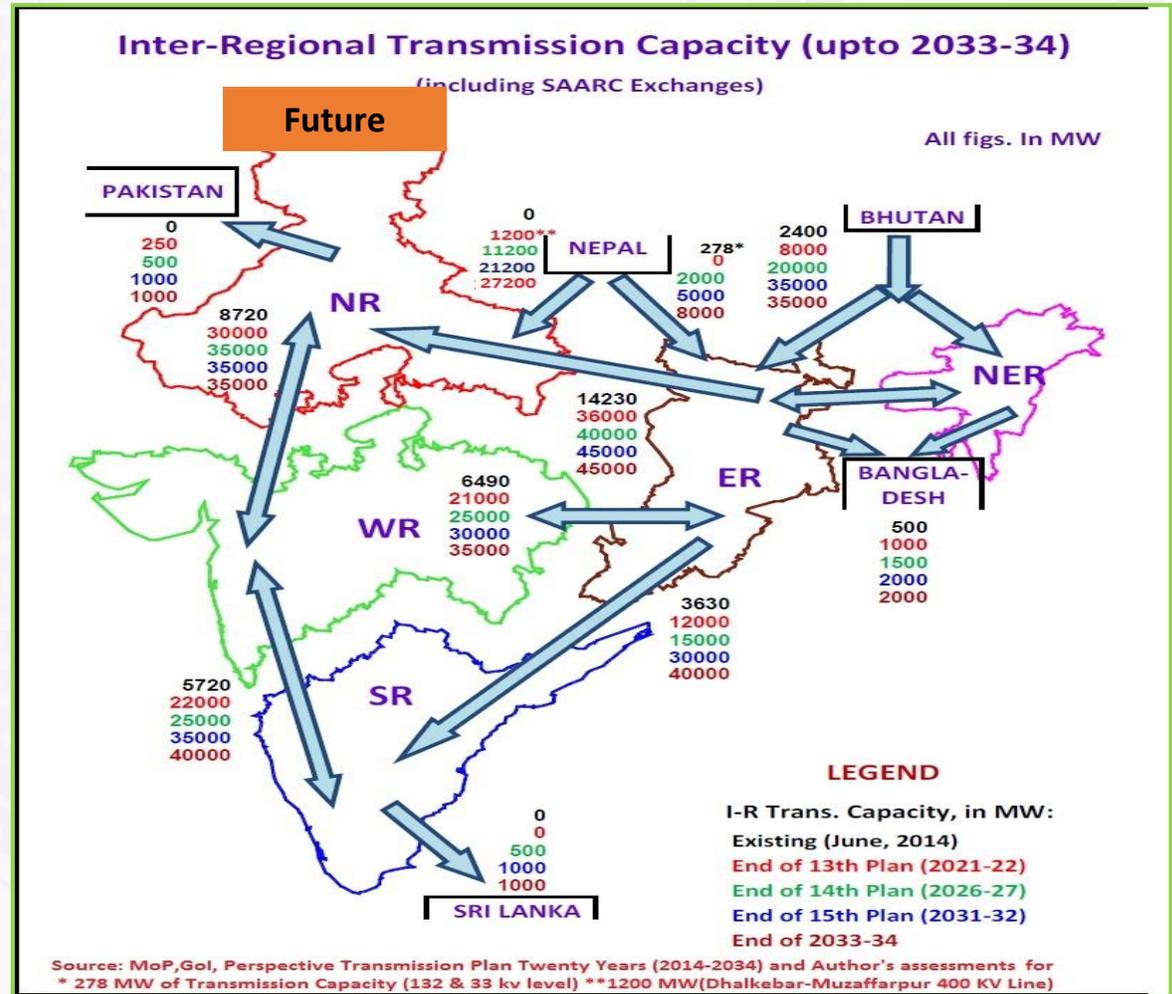
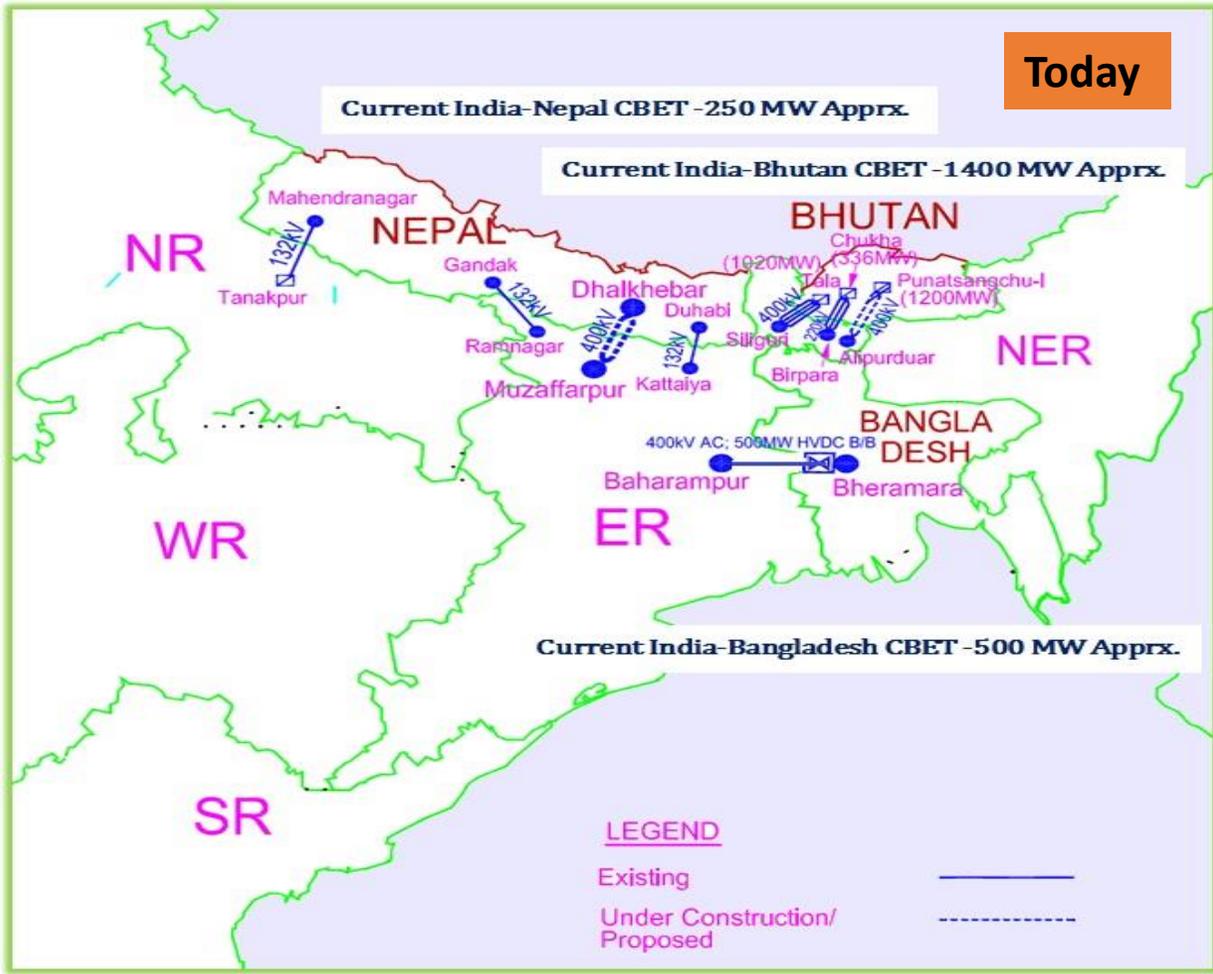


TF-3 :

● **Study 1:** “Assessment and recommendation of commercial terms & conditions for Cross Border Electricity Trade (CBET) and suggesting the model Of Power Exchange in South Asian region” *(Draft Report Prepared – Ongoing)*

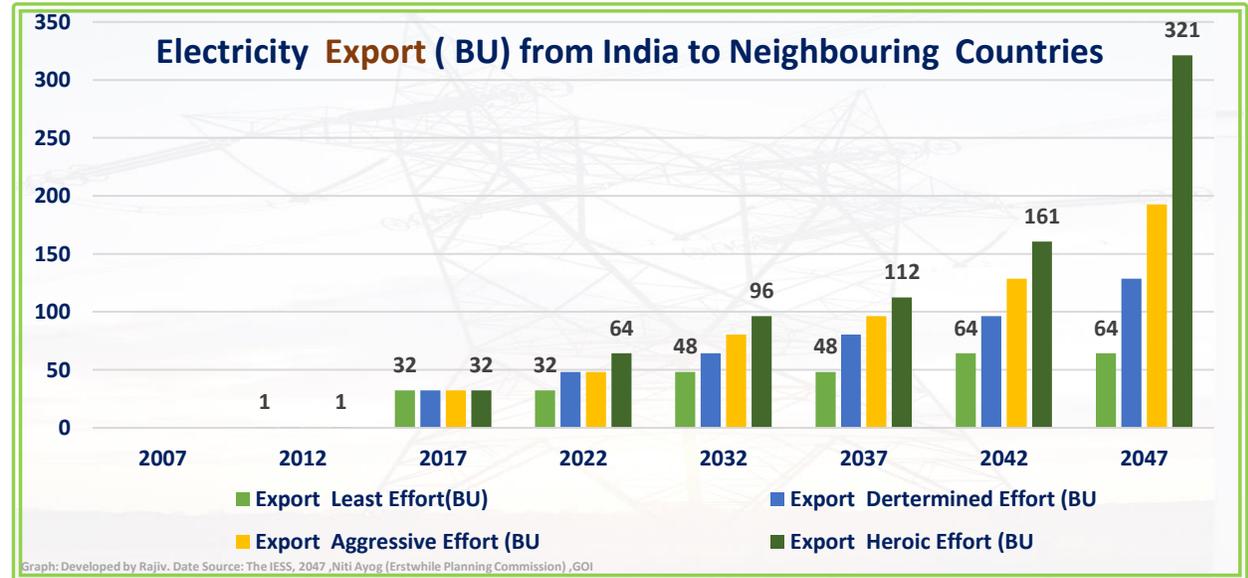
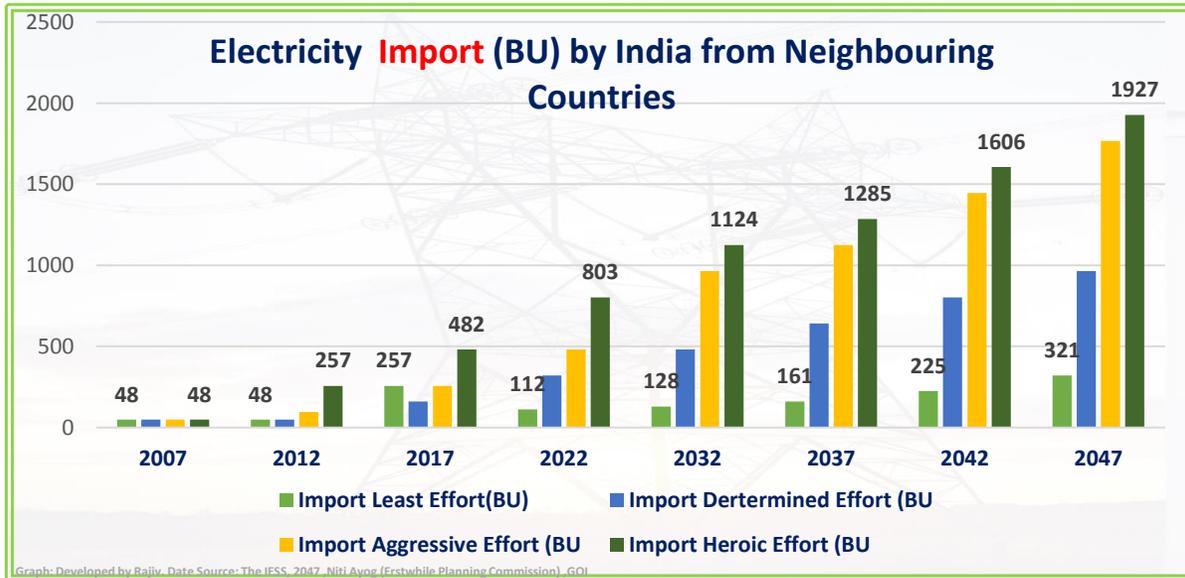
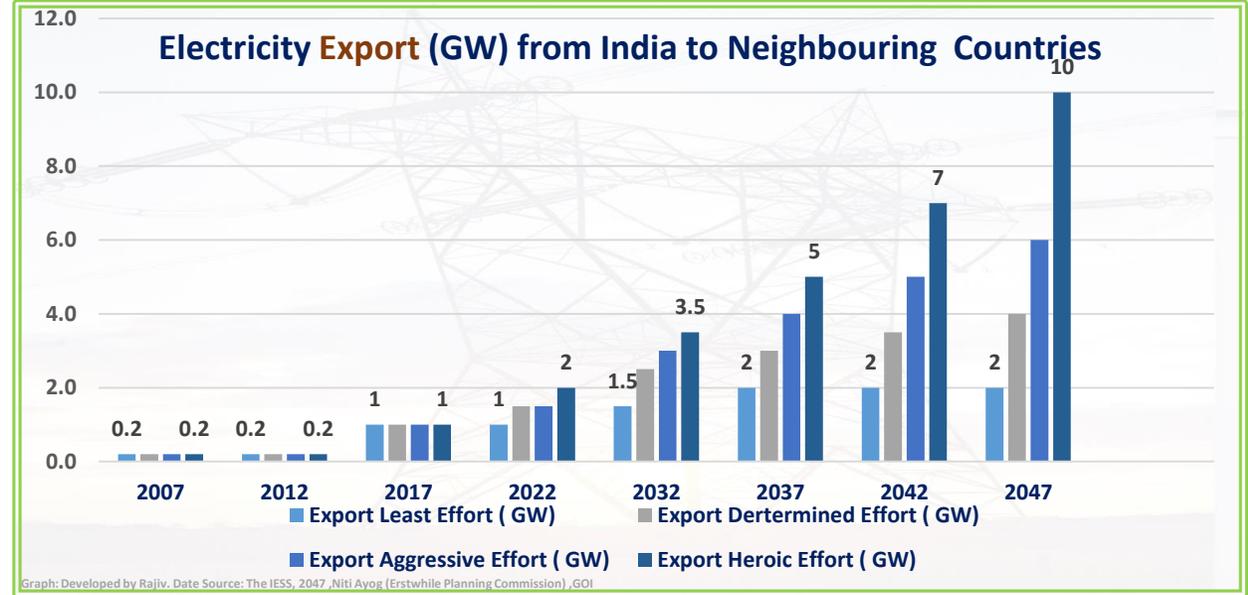
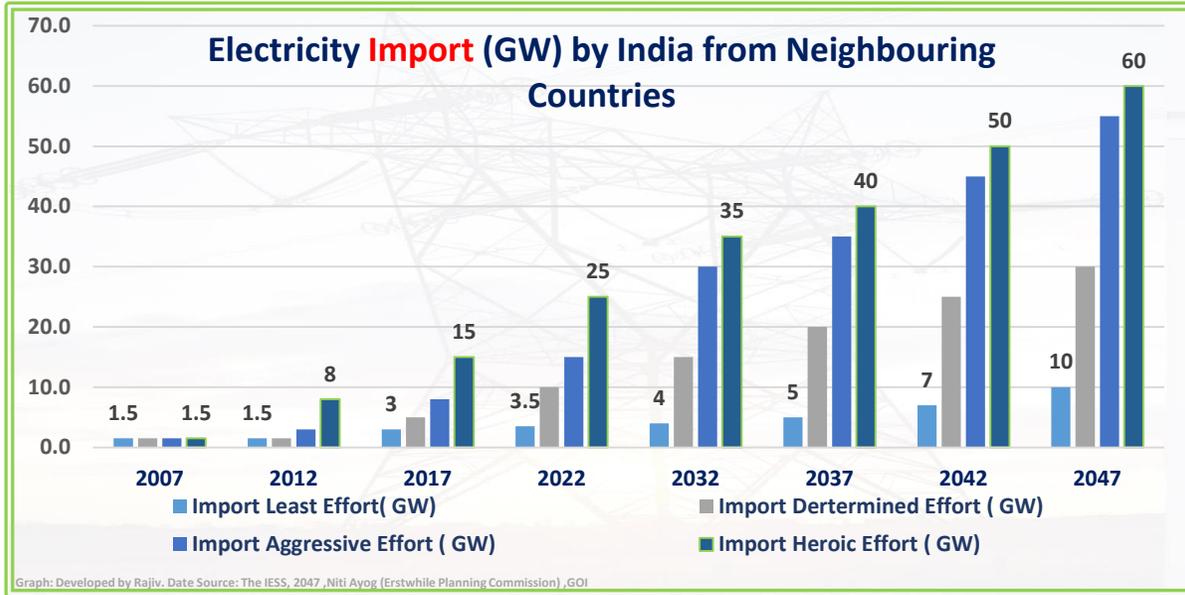
● **Study 2:** Implementation of Pilot Market & Market rules *(Process initiated)*

Background : What is the CBET Vision ?



Significant Transmission System Interconnection (Both AC and DC) are being Planned and Proposed.
Bangladesh is in the process of Planning to Import around Apprx. 6000 MW by 2034 (PMSP 2015-JICA Presentation, 4th June, 2015)

India: Cross Border Electricity Trade Export and Import by India from Neighbouring Countries



Background : Need for Harmonization for Safe, Reliable and stable operation of the Interconnected Power system

With High Level of Cross Border Interconnection being envisaged, it is obvious that for safe, reliable and stable operation of the interconnected transmission system, the various technical aspects of grid codes, operating procedures and standards needs to be harmonized/coordinated.

Harmonization means to have procedures, schedules, specifications of systems to make them uniform or mutually compatible and manage the differences & inconsistencies among measurements, methods.

Compatibility has to be there depending on the type of interconnection.

In case of a synchronous interconnection, voltage, basic insulation strength, nominal frequency and protection scheme must match.

In case of asynchronous interconnection though may require less level of harmonization, the tripping of HVDC terminal would itself can constitute a disturbance in terms of loss of load or loss of supply at bigger level.



USAID
FROM THE AMERICAN PEOPLE

SARI/EI



Scope of Work : Objectives

Scope of Work : Objectives

Review of the Grid Codes of the respective South Asia nations covering procedures/codes/standards such as Power system operating procedures, protection code, metering code, connection code, planning code, system security, demand estimation systems, outage planning, recovery procedures etc.

Identify relevant provisions in each of the above documents operating procedures/ Grid codes and standards that have the potential to impact “cross border electricity trade”;

Suggest possible measures with necessary changes to be made in each of the above of the respective SA countries to facilitate/promote optimal and economic “cross border electricity trade only” in the South Asia region.



SARI/EI Task Force-2 Study on Harmonization of grid codes, operating procedures and standards to facilitate/promote cross border electricity trade in the south Asia region: Status Update

SARI/EI Task Force-2 is currently carrying out the Study on Harmonization of grid codes, operating procedures and standards to facilitate/promote cross border electricity trade in the South Asia Region.

M/s PRDC, Bangalore is conducting the study.

Methodology and approach has been finalized by Members.

Preliminary Review and Comparison of the Grid Codes and Gap Analysis has been conducted. The same was presented during the Combined Meeting of Task forces and 5th Meeting of TF-2.

Overall approach for harmonization of Grid Codes was discussed and finalized.

International best practices (European, NERC-North American Electric Reliability Corporation, SAPP) and Impact Analysis of Grid Codes & Operating Procedures has been analysed and reviewed.

Comprehensive framework guidelines along with Draft Codes are prepared

Study Methodology

Phase I 1. Project Inception

- 1.1 Project Kick-off
- 1.2 Work Plan Preparation
- 1.3 Preliminary Data Mapping, Comparison of South Asian Grid Codes and Gap Analysis
- 1.4 Inception Report generation
- 1.5 TF/IRADe Meeting

Phase II 2. Project Interim Analysis

- 2.1 Project related Data Collection
- 2.2 Power Transmission Standards Review
- 2.3 Standards Gap Analysis
- 2.4 Organizational Structure Review
- 2.5 TF Meeting

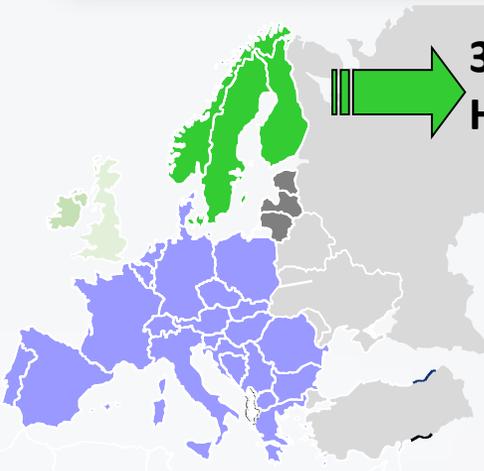
Phase III 3. Impact Assessment & Regional Grid Code Creation (Now Framework Guidelines will be prepared as suggested by members)

- 3.1 Review of international grid codes on cross border trading
- 3.2 Impact Analysis of Grid Codes & Operating Procedures with respect to the International Review.
- 3.3 Draft Interim Report
- 3.4 Comments from TF members
- 3.5 Recommendation for CBET supportive Framework Guidelines
- 3.6 Draft Final Report

Phase IV 4. TF Workshop & Final Report Submission

- 4.1 Final TF Workshop
- 4.2 Final Report Submission
- 4.3 Identification of Training Requirements to ensure proper implementation of Framework Guidelines

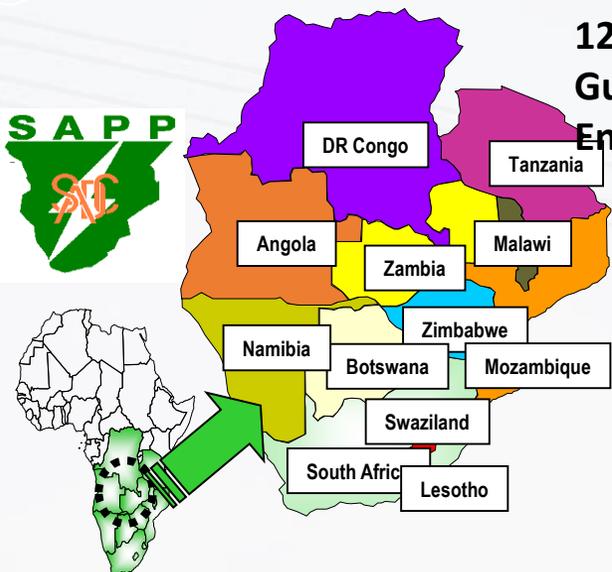
International Experience Review and Impact Analysis



34 European Countries : ENTSOs
Have developed Framework Guidelines(FG) and Network Codes across key areas:



Connection, Operational (Operational Security , Planning ,Scheduling ,L/F Control & Reserve),Market Codes(CA and Congestion Management, Electricity Balancing)



12 Countries:
Guidelines on Operation ,Planning and Environment



NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico.
Developed Various Standards related to Reliability Operation

International experience Review and Impact Analysis was carried out across a) Planning Code b) [Connection Code](#) c) [Operation Code](#) d) [Metering Code](#)

Overall Approach for Grid Code Harmonization/Coordination in South Asia

Framework Guidelines

Development of Framework guidelines on the identified Areas (contains explanatory statement along with draft code for each identified areas)



Cross Border Grid code

Development of codes based on Framework guidelines by the relevant authorities



Agreement & Operationalization of code

Development of Framework Guidelines

The Framework Guidelines will be comprehensive in nature and shall contain

**Impact
analysis**

**Explanatory
statement**

Draft code

**Implementation
Provisions**

The proposed framework shall not be intended to replace the existing national grid codes for non-cross border issues but to harmonise/Coordinate the critical issues concerning cross border trade.

Identified Areas for Framework Guidelines

Framework Guidelines

Planning Guidelines

**Connection Guidelines
(including metering &
protection guidelines)**

Operational Guidelines

Scheduling & Dispatch

The draft code can be adopted fully or in parts by the relevant authorities and can form the basis for harmonising/Coordination of the existing national codes in the identified areas for CBT.

Draft Guidelines

Planning Guidelines

- It provides various guidelines to be adopted for planning and development of system studies

Connection Guidelines

- It specifies a minimum of technical, design and operational plant criteria to be compiled with by the existing and prospective users.
- It includes the meter placement, compliance of meters according to standards in terms of accuracy levels, accessibility of the meters, maintenance responsibility of meters etc.,
- It covers the general protection guidelines to be followed for the generator, transmission licensees.

Operation Guidelines

- It contains details for high level operational procedures for example demand control, operational planning and data provision

Schedule and despatch Guidelines

- It describes the procedures to be adopted for Scheduling and despatch of generation and allocation of power drawl



USAID
FROM THE AMERICAN PEOPLE



Planning Guidelines

Planning Guidelines: Planning Philosophy

Master Plan with a planning horizon of 10 years has been suggested as the basis for planning the interconnected network among member countries and reviewed every alternative year.

As the cross-border interconnection is expected to cater for the long term requirements of member countries, sufficient forecasting of demand and generation planning shall be carried out.

From practical considerations the load variations over the year shall be considered as under:

- Annual Peak Load
- Seasonal variation in Peak Loads for Winter, Summer and Monsoon
- Seasonal Light Load or Off-peak load (for Light Load scenario, motor load of pumped storage plants shall be considered)

The load-generation scenarios shall be worked out so as to reflect in a pragmatic manner due to typical daily and seasonal variations in load demand and generation availability which impact the cross border power flow along with the impact of RE i.e., wind & solar.

Planning Guidelines: Transmission Planning Criterion

| | |
|---|-----------------------|
| Nominal Frequency | 50 Hz |
| Steady State Operational Frequency Limits | + 0.05 Hz to - 0.1 Hz |
| Instantaneous Frequency Limits | ± 0.8 Hz |

The temporary over voltage (peak phase voltage) limits due to sudden load rejection shall be:

- 1.4 p.u. for a 765 kV system
- 1.5 p.u. for a 400 kV & 500 kV system

The switching over voltage (peak phase voltage) limits shall be:

- 1.9 p.u. for a 765 kV system
- 2.5 p.u. for a 400 kV & 500 kV system

Short circuit ratio (SCR) at the converter terminals of HVDC installations shall be greater than 3.

Planned maximum sub-transient short circuit fault levels shall not be greater than 80% of equipment ratings.

Line to earth voltage during single line to earth faults should not rise above 80% of the rated line to line voltage.

Planning Guidelines: Transmission Reliability Criteria

Criteria for system with no contingency ('N-0')

For the planning purpose all the equipment's shall remain within their normal thermal loadings and voltage ratings.

The angular separation between adjacent buses shall not exceed 30 degree

Voltage step resulting from capacitor/reactor switching shall not exceed 3.0%.

Criteria for system with single contingency ('N-1')

All the equipment's in the transmission system shall remain within their normal thermal and voltage ratings after a disturbance involving loss of any one of the following elements , but without load shedding / rescheduling of generation:

Outage of a 400 kV single circuit

Outage of a 400 kV single circuit with fixed series capacitor

Outage of an Inter-Connecting Transformer

Outage of a 765 kV single circuit

Outage of one pole of HVDC bi-pole

The angular separation between adjacent buses under ('N-1') conditions shall be permitted up to 30 degree

The system shall be capable of withstanding the loss of most severe single system infeed without loss of stability.



USAID
FROM THE AMERICAN PEOPLE



Connection Guidelines

Connection Guidelines: Technical Requirements

The Agreement shall be mandatory between the applicant and the national transmission utility of the member country at the synchronous connection point.

To comply with the connection code(s), the user shall be capable to meet the minimum standard requirement at the inter connection point which is defined by:

- Reactive power requirements
- Frequency and voltage parameters
- Short-circuit fault levels
- Metering system
- Protection devices
- Simulation Models
- Data and Communication Facilities & Event Recording Instruments including real time data gathering with time stamping
- Cyber Security
- Schedule of cross border assets of member country grid

Reactive Power Requirements

- Respective country's power authority need to ensure that reactive power requirements are kept at bare minimum (within lead/lag 0.97 power factor and operated within the grid code voltage level) at connection point.
- In case of HVDC link or asynchronous link, the voltage is to be maintained within the limits by the respective transmission agencies to prevent mal-operation of the HVDC links.

Connection Guidelines: Connection Guidelines

Frequency

- User shall be capable of staying connected to the network and operating within the Frequency ranges and time periods which is specified by the system operator or automatically disconnect at specified frequencies if required by the operator.
- Recommended frequency band of operation shall be within 49.9 Hz to 50.05 Hz to maintain security of the total interconnected system. However all the connecting equipments shall withstand the frequency profile as in Table below.

| Frequency | Time period for operation |
|----------------|--|
| 47.5– 48.5 Hz | 90 minutes |
| 48.5– 49.0 Hz | To be defined by each system operator, but not less than the period for 90 minutes |
| 49.0 – 51.0 Hz | Unlimited |
| 51.0 – 51.5 Hz | 30 minutes |

Voltage

- At the point of Interconnection, acceptable range of operating voltages shall be $\pm 5\%$ for 400 kV and above transmission voltage levels but all the connected equipment shall withstand the voltage variation of $\pm 10\%$.

Short-Circuit Fault Levels

- The coordination forum or the planning committee shall provide minimum and maximum short circuit level of the interconnecting substation of cross-border link for various possible scenarios

Connection Guidelines: Protection Requirements

Protection schemes relevant for the power generating module and the network shall be coordinated and agreed between the relevant network operator and the power generating facility owners.

Protection scheme for Generation Facilities

| | | |
|---|---|--|
| External and internal short circuit | Inter-area oscillations | Rate of change of frequency |
| Over-/under-excitation | Inrush current | Neutral voltage displacement |
| Stator and rotor overload | Asynchronous operation (pole slip) | Inverse power |
| Asymmetric load (-ve phase sequence) | Power generating module line protection | Over fluxing (U/f) |
| Over-/under-voltage at the connection point | Protection against inadmissible shaft torsions (for example, sub-synchronous resonance) | Backup schemes against protection and switchgear malfunction |
| Over-/under-voltage at the alternator terminals | Unit transformer protection | |

Protection Scheme Devices Of Demand Facilities Shall Cover -

- External and internal short circuit;
- Over- and under-voltage at the connection point;
- Over- and under-frequency;
- Demand circuit protection;
- Unit transformer protection; and
- Backup schemes against protection and switchgear malfunction.

Fault Recorders at Generator And Transmission facilities shall -

- Exist at all transmission lines, autotransformers or phase-shifters connected to busses; shunt capacitors, shunt reactors, Individual generator line interconnections, Dynamic VAR devices and HVDC terminals
- Record duration shall be a minimum of one (1) second
- Have a minimum recording rate of 16 samples per cycle

Connection Guidelines: Metering Requirements

Bi-directional meters shall be installed at the connection point between the transmission connected grid of the participating countries, between the transmission grid & the generator and between the transmission connected grid & the distributor who are part of cross country power flow

- Minimum standard of accuracy of meters shall comply with the latest IEC standards - **Main and Check Meters:** The minimum standard of accuracy of Meters shall be 0.1%
- For the voltage and current transformers, accuracy shall be 0.2% and the secondary burden shall be maintained between 25% and 100% of rated values.
- **The metering shall record :** Bus voltage; Frequency; Active Power, Energy; Reactive Power; Current; Any other facilities as agreed in the connection agreement.

It is recommended that Energy Accounting and Audit functions shall be carried out by coordinating forum or the planning committee (as per planning guidelines) or separate agency as required.

All Main energy meters for interconnection shall be owned by Government designated Transmission Licensee in whose premises the meter is located and the check meters shall be owned by the other member country Licensee.

Location of Meters

| Stages | Main Meter | Check Meter | Standby Meter |
|--|--|-------------------------|--|
| Generating station not directly connected to the Transmission system | On all outgoing feeders | On all outgoing feeders | H.V side of the Generator Transformers H.V side of all station auxiliary Transformers |
| Transmission connected | At both ends of the Interconnected Transmission line. Meters at both ends shall be considered as main meters for respective licensees. | - | There shall be no separate standby meter. Meter installed at other end of the line in case of two different licensees shall work as standby meter. |



USAID
FROM THE AMERICAN PEOPLE



Operational Guidelines

Operational Guidelines: System Security Aspects

The list of important grid elements that impacts the CBET shall be prepared and published in advance.

No important element of the interconnected grid shall be deliberately opened or removed from service at any time, except

- Under an emergency, and conditions in which such isolation would prevent a total grid collapse and/or would enable early restoration of power supply
- For safety of human life
- When serious damage to costly equipment is imminent then isolate the equipment by suitable disconnection without endangering security of the system
- Such isolation is to be specifically instructed after mutual agreement of the System Operators of the two countries through specific messages exchanged to this effect.

Any prolonged outage of power system elements, which is causing or likely to cause danger to the grid or sub-optimal operation of the grid, the same shall be regularly monitored by the respective regional heads and be reported

The exchange of information shall happen over a common platform and include sufficient information on who is responsible for exchange of what data, containing how much detail, at what frequency and in what format along with the need for time stamping.

Operators shall exchange the protection set-points of the lines, reliability entities of relay or equipment failures, revised fault analysis study, letters of agreement on settings, notifications of changes, or other equivalent evidence that will be used to confirm that there was coordination of new protective systems or changes in the transmission systems.

Operational Guidelines: System Security Aspects

All thermal and hydro generating units shall follow their respective Grid codes and shall have AVR's & Governors in operation with tuned PSS for effective damping of oscillations. Adequate operating reserves (Primary/Secondary/Tertiary) shall be made available. The cross border links shall facilitate in the primary reserve process. However, it is desirable that the adequate control is established to restore the power flow to the scheduled level within a block period.

| | System Security Limits | | |
|--|--|--|--|
| | Normal | Alert | Emergency |
| Voltage (400, 500 & 765 kV) | ± 5% | ± 5% | ± 10% |
| Frequency – for synchronously interconnected system | Nominal: 50Hz Steady state limits: +0.05Hz to -0.1Hz Instantaneous limits: ± 0.8Hz | Exceeds steady state limits for upto 10 mins | Exceeds steady state limits for >10 mins up to 20 mins |
| Equipment loading | Within Limits | Within Limits | Exceeds limits of short term overload |

Special protection system (SPS) to prevent cascading with the outages Wind and solar generation shall be treated as a must-run station, unless instructed otherwise by respective operators on consideration of grid security.

The protection strategy and concepts shall be reviewed every five years.

Protective relay settings shall not limit transmission loadability nor interfere with system operators' ability to take remedial action to protect system reliability and shall be set to reliably detect all fault conditions and protect the electrical network from these faults.



Operational Guidelines: Demand Estimation for Operational purposes

The existing demand estimation procedure as per the grid code of the respective member country can continue for daily/ weekly/ monthly/ yearly basis for current year for load - generation balance planning. The present guidelines is for information purpose only

Each region shall carry out its own demand estimation from the historical data and weather forecast data from time to time. All necessary data and information shall be provided by relevant entities as required for demand estimate. The monthly estimated demand shall be shared with the operation planning authorities.

Based on the demand estimation for operational purposes on a daily/weekly/monthly basis, mechanisms and facilities shall be created at the earliest to facilitate on-line estimation of cross border power flow for each 15 minutes block.

Operational Guidelines: Congestion Management

Commercial principles for congestion management need to be developed in order to facilitate cross border transactions. Transmission agencies shall be responsible to continuously monitor and adopt curative measures, when necessary.

- For long term commitments, re-dispatch and counter flow measures may be followed.
- For medium and short term commitments, load curtailment shall be the last resort.
- The respective member country utilities shall also implement automatic demand management like rotational load shedding, demand response.

The frequency thresholds of 49.5 Hz can be defined for automatic shedding of loads and is recommended and the loads should be classified in four groups,

- loads for scheduled power cuts / load shedding,
- loads for unscheduled load shedding,
- loads to be shed through under frequency relays & df/dt relays
- loads to be shed under any Special Protection Scheme.

All manual load shedding shall be coordinated between operators and demand facilities which shall be maintained by the respective country authorities without affecting the grid security

Operation- Outage Planning

The procedure for preparation of outage schedules for the elements of the interconnected grid shall be formed by grouping responsibility areas.

Outage planning assets are classified as relevant assets and critical assets. The outage coordination planning takes all relevant assets into account.

The planning shall be split into three time horizons, the long term (a year ahead), the medium term (monthly reassessment) and the short term planning (week ahead).

The coordinated availability plan shall have the following details for each relevant element:

- Availability Status, which may be one of the following three states:
 - **Available:** the Relevant Asset is capable of and ready for providing service, whether or not it is actually in operation.
 - **Unavailable:** the Relevant Asset is not capable of or ready for providing service;
 - **Testing:** the capability of the Relevant Asset for providing service is being tested. This status may be used only during time periods between first connection and final commissioning or immediately after maintenance.
- Reason for unavailability
- Conditions that need to be fulfilled before making asset unavailable
- Restoration time

Operation- Recovery Procedure

Recovery procedures are defined

- Each operator has to evaluate the number of units capable of black start and islanded operation to contribute to the restoration.
- Operators have to know the status of the component of their power system after a blackout.
- During re-energization, the relevant region's load frequency secondary control is switched to frequency control mode while the other load frequency secondary controllers remain in frozen control state.
- The consumption and production are balanced by the resynchronization leader with the aim of returning near to 50 Hz, with a maximum tolerance of ± 200 mHz under the coordination of the area's regional head.

Operation- Coordination Between System Operators

Each operator shall provide the following information for the purposes of system defence plan procedures and restoration plan procedures:

- To neighboring operators
- To the regional head
- To Transmission connected distribution systems

Reporting procedures in respect of all events in the system to all users and all verbal notifications may be backed up with appropriate written reports.

To facilitate smooth operation, different coordination forums are formed which is given below and this groups shall recommended to meet once every calendar quarter

- Operation and Protection Coordination Group
- The Commercial Coordination Group

In addition to the above coordination forums, the transmission system owners of the respective countries may coordinate with each other for various aspects pertaining to the O&M of the transmission assets in their respective jurisdiction.



USAID
FROM THE AMERICAN PEOPLE



Scheduling & Dispatch Guidelines

Scheduling & Forecasting Guidelines: Objective & Applicability

Objective:

- Ensuring operational security;
- Ensuring optimal use of the transmission infrastructure;
- Ensuring and enhancing the transparency and reliability of information;
- Contributing to the efficient long-term development of the electricity transmission system by accurate forecasting;
- The procedures to be adopted for scheduling of the net injection / drawals of concerned entities on a day-ahead basis with the modality of the flow of information between the regional entities

Applicability

- This Guideline are applicable for all member countries which are involved in cross border grids.

Scheduling & Dispatch Guidelines: Introduction

Computation of the Available Transfer Capability (ATC) is suggested. System operator shall consider the technical limit imposed by the system components, the thermal line limits, bus voltage limits and stability limit.

Each time block shall be for a duration of 15 minutes and a common time of Indian Standard Time (IST) can be adopted for uniformity.

Transmission Losses will be apportioned between two countries based on a mutually agreed methodology.

- Transmission System Losses would be borne in kind by the utilities as per the quantum declared for the respective area of jurisdiction in the interim.

The (firm) power traded would normally be treated as a 'must-run' and thus would not be subject to revision / curtailment except under conditions which pose a threat to the System Security of either of the participating countries.

Control on its generation and / or load to maintain its interchange schedule with other member countries whenever required and contribute to frequency regulation of the synchronously operating system.

Take the responsibility of coordinating the scheduling of a generating station, within the country area, real-time monitoring of the station's operation in its availability declaration, or in any other way revision of availability declaration and injection schedule, switching instructions, metering and energy accounting, outage planning, etc.

Scheduling & Dispatch Guidelines: General Guidelines

The system operators shall publish a general scheme for calculation of the Total Transfer Capability (TTC) and Available Transfer Capability (ATC) based on the electrical and physical realities of the network.

In case of congestion, agreed commercial mechanism is to be followed.

The Available Transfer Capability (ATC) shall consider Capacity calculation timeframes (Long term, Short term, Intraday), Capacity calculation regions, Common grid model methodology

The methodologies for the capacity calculation, which shall include methodology for determining the reliability margin; operational security limits, contingencies relevant to capacity calculation and allocation constraints that may be applied

Scheduling & Dispatch Guidelines: Demarcation of Responsibilities

Operated as power pools with their own scheduling and dispatch process, in which the respective system operators shall have the total responsibility for

- Scheduling/dispatching of their own generation.
- Regulating the demand of its control area.
- Scheduling their drawal.
- Regulating the net drawal of their control area.

The member country entities shall ensure

- there is no over drawl when frequency is 49.5 Hz or below.
- When frequency is higher than 50.2 Hz, the actual net injection shall not exceed the scheduled dispatch for that time block.

The generating stations and sellers shall be responsible for their power generation/power injection as per daily schedules

The coordinating member may direct the system operator to increase/decrease their drawal/ generation in case of contingencies e.g. overloading of lines/transformers, abnormal voltages, threat to system security. Such directions shall immediately be acted upon.

The coordinating forum shall be responsible for computation of actual net injection/drawal of on the cross border link, 15 minute-wise, based on the above meter readings.

Scheduling & Dispatch Guidelines: Timeline

| Time | Activity |
|----------|--|
| 0800 hrs | Member country Load Dispatch Centres shall compile their foreseen MW and MWh generation capabilities for the next day and submit the cross-border power transfer, i.e., from 0000 hrs to 2400 hrs of the following day to the coordinator heads. |
| 1500 hrs | Member country Load Dispatch Centres shall compile their foreseen load pattern for the next day and submit revised cross-border power transfer to the coordinator heads. |
| 1800 hrs | All coordinator heads together or a scheduling authority decides the best dispatch and drawal schedule for cross border interconnection and each coordinator head conveys the net dispatch schedule and the net drawal schedule through cross border interconnection to each member country load dispatch centres under its control. |
| 2200 hrs | Any modifications in load or generation shall be brought to the notice of the coordinator head by the member country dispatch centre. |

Each time block shall be for a duration of 15 minutes and a common time of Indian Standard Time (IST) can be adopted for uniformity.

The priority of scheduling of power over the cross border link would be long-term contracts, medium term contracts and short term bilateral contracts (up to 3 months) in that order.

Scheduling & Dispatch Guidelines: Deviation Settlement

Special energy meters at all interconnections between the countries for recording the actual net import / export MWh and MVarh on a 15-minute basis . Deviation from schedule on the Cross Border Link will be calculated for each 15 minute time interval.

Energy accounting is on weekly basis.

Transmission charges for wheeling of power up to the international interconnection for the international trade would be borne by both the buyer and the seller as per the prevailing methodology in the respective country.

Transmission charges for the international interconnection would be payable by the market participants as per the charges mutually agreed between the participating member countries.

Operation charges, taxes, levies and other statutory duties / levies would be payable to the system operators by the participants as per the prevailing laws of the land.

A suitable payment security mechanism for transmission charges, system operation charges and charges of imbalance would be put in place by the participating member countries.

The member states shall put into place through mutual agreement a mechanism for dispute resolution.

Scheduling & Dispatch Guidelines: Charges for Losses

Transmission system operators shall be compensated for energy losses based on an estimate of what losses would have been incurred in the absence of transits of electricity.

An agency shall be established comprising of representatives of all participating countries for the long term, a fund shall be established to compensate energy losses incurred. The fund may be referred to as Cross Border System Operator Compensation (CBSOC) Fund.

All contributions and payments shall be made as per the agreements in place and the agency shall be made responsible for relating to the CBSOC Fund as follows

- To establish the arrangements for the collection and disbursement of all payments
- To determine the timing of payments.
- To publish report annually on the implementation of the mechanism (normally on 15 minutes time block) and the management of the fund.
- To carry out the loss calculation and shall publish this calculation and its method in an appropriate format.

The amount of losses incurred on a transmission system shall be established by calculating the difference between

- The amount of losses actually incurred on the transmission system during the relevant period.
- The estimated amount of losses on the transmission system which would have been incurred on the system during the relevant period if no transits of electricity had occurred.



USAID
FROM THE AMERICAN PEOPLE



Implementation Provisions

Implementation Provisions: Philosophy

It is envisaged that the framework guidelines and draft codes would be agreed between the regulatory entities of SAC, initially; these will be non-binding in nature and may not have a formal legal status. The following approach is proposed in order to ensure this transition:

The framework guidelines and draft codes are adopted by the SAFER and may be recommended to the national regulators in South Asian countries for adoption as a non-binding framework, guiding grid code harmonization/coordination for Cross-Border Electricity Trade.

For adoption of the framework guidelines and draft codes by each of regulatory agencies in the member countries in the South Asian region for the purpose of cross-border energy trading in their grid code, National electricity regulators may need to identify specific changes that are required in the national grid codes. The proposed guidelines may be adopted in Toto or in parts as appropriate.

Existing National electricity Grid Code Regulations may be updated based on the framework guidelines and draft codes, are modified to ensure full consistency.

Additional studies/reviews undertaken in due course can contribute in defining the national grid code regulations in a more detailed form, eventually leading to the updating of guidelines and codes.

Framework guidelines and draft codes are updated and adopted for governing cross-border trade transactions (binding nature). The legal effect could gradually be increased by adoption through the national country governments/regulatory authorities through the national grid code regulations.



USAID
FROM THE AMERICAN PEOPLE

SARI/EI



Implementation Provisions: Philosophy

The above steps will require consensus building and hence, will need to be facilitated through a strong institutional sponsor. SARI/EI Task Force-1 has recommended a to establish South Asian Forum of Electricity Regulators (SAFER) to manage this process in close coordination with various regional bodies, transmission utilities including the proposed regional electricity regulatory authority, the South Asia Association for Regional Cooperation (SAARC) secretariat, technical committees, forums in the area of facilitating cross border electricity trade.

Implementation Provisions: Coordination Groups

The coordination groups/ standing committees can work under the South Asian Forum of Transmission Utility (SAFTU).

Design Coordination Group

- The Design Coordination Group would prepare the Detailed Project Report on the basis of various activities like detailed survey of the routes of transmission lines, assessment of size & location of substation land, finalization of the details of design parameters of the substations and transmission lines etc for cross border trade.

Project Monitoring Group

- The project monitoring group would monitor different milestones of the project after completion of DPR. The detailed activities need to be monitored include tendering activities, forest and environmental clearances, acquisition of land for substation, construction of the project, commissioning of the project etc.

Operation and Maintenance Coordination Group

- The Operation and Maintenance Coordination Group needs to be constituted for smooth operation and maintenance of the interconnecting project after its commissioning. The scope would also include maintenance of associated communication facilities, coordination of protective devices, maintenance coordination etc.
 - Operation and Protection Coordination Group
 - Commercial Coordination Group

Co-ordinating Agency for Planning



USAID
FROM THE AMERICAN PEOPLE



Thank You