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# 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

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# Background

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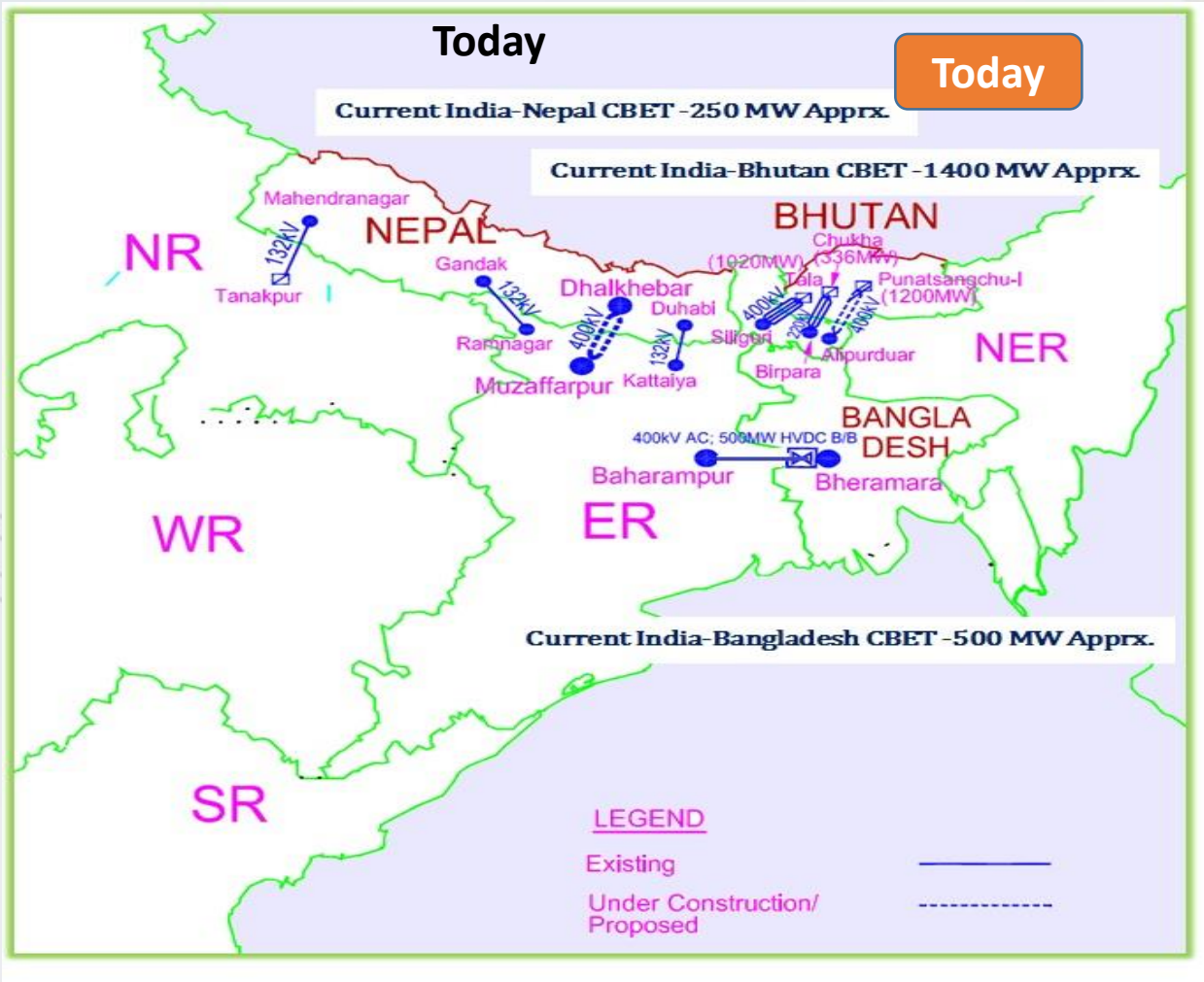
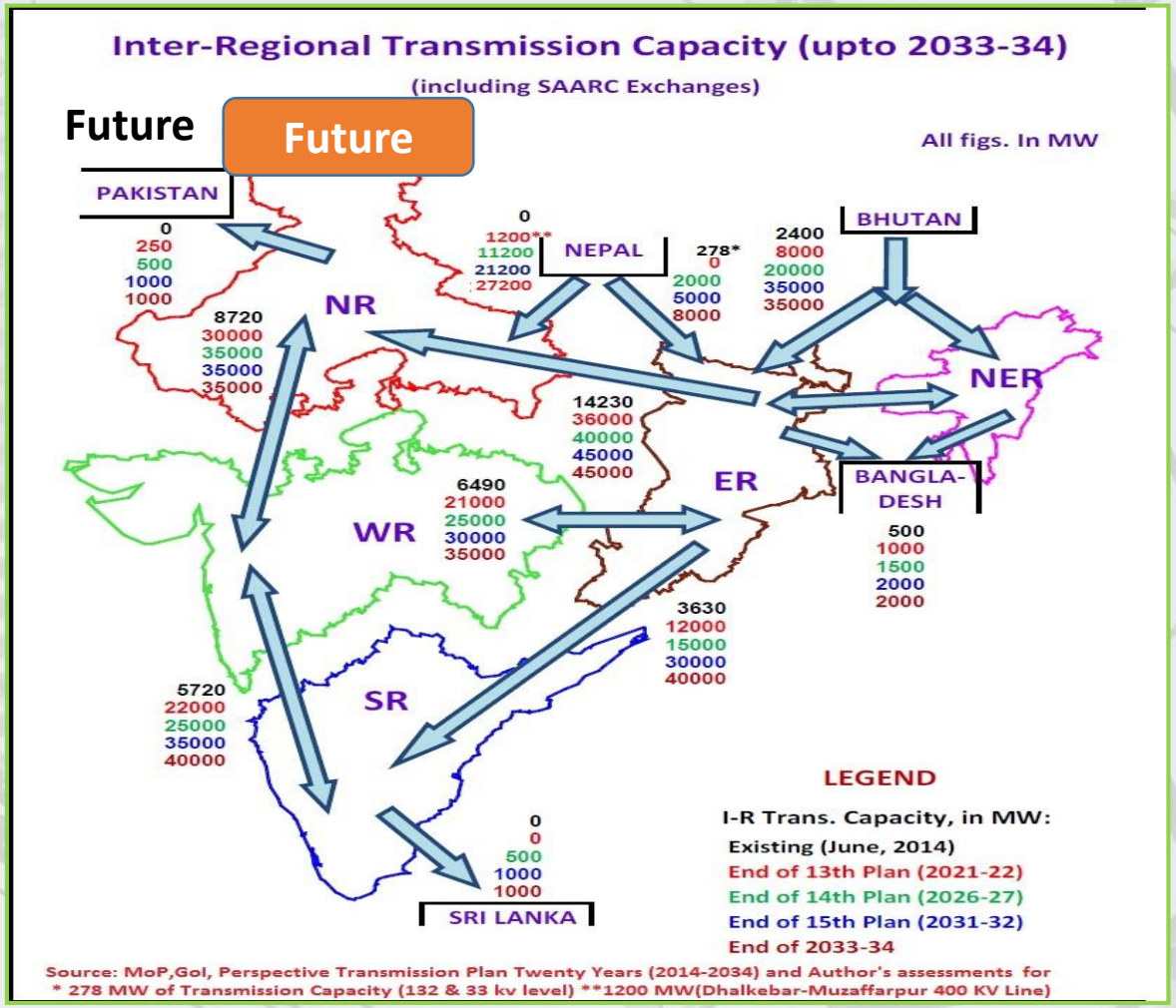
# Background : CBET Vision

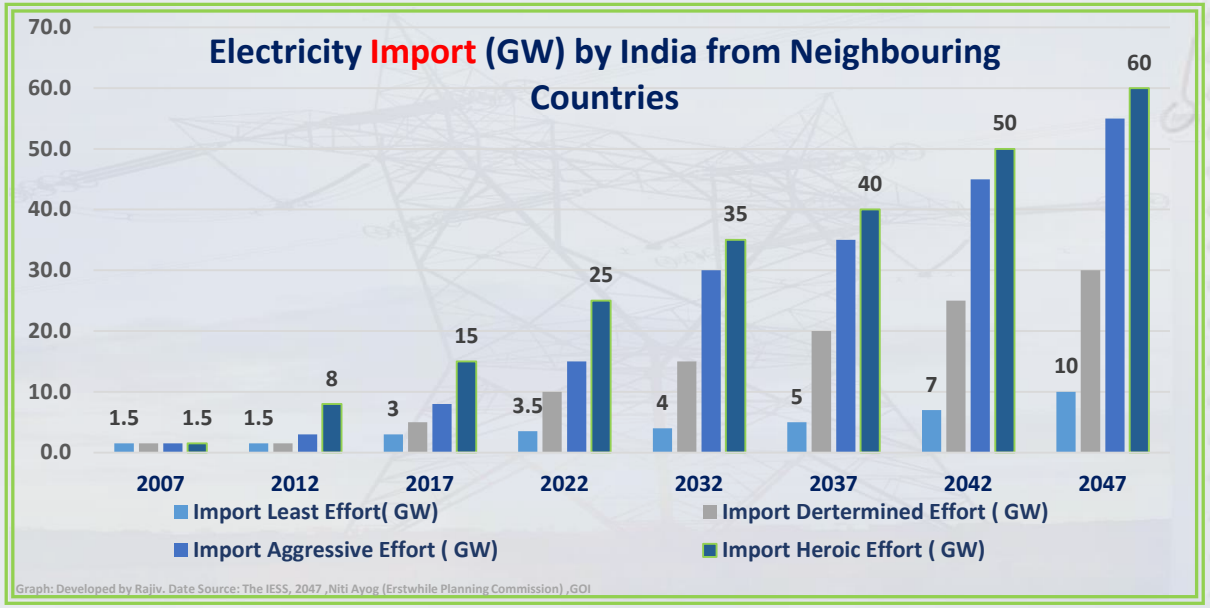


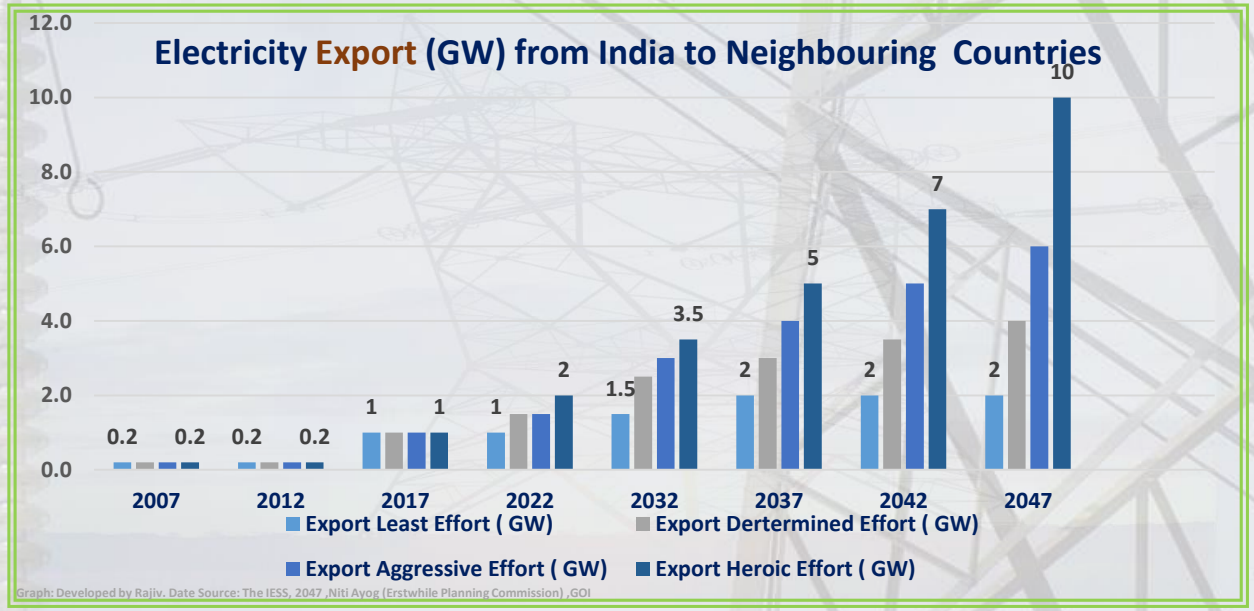



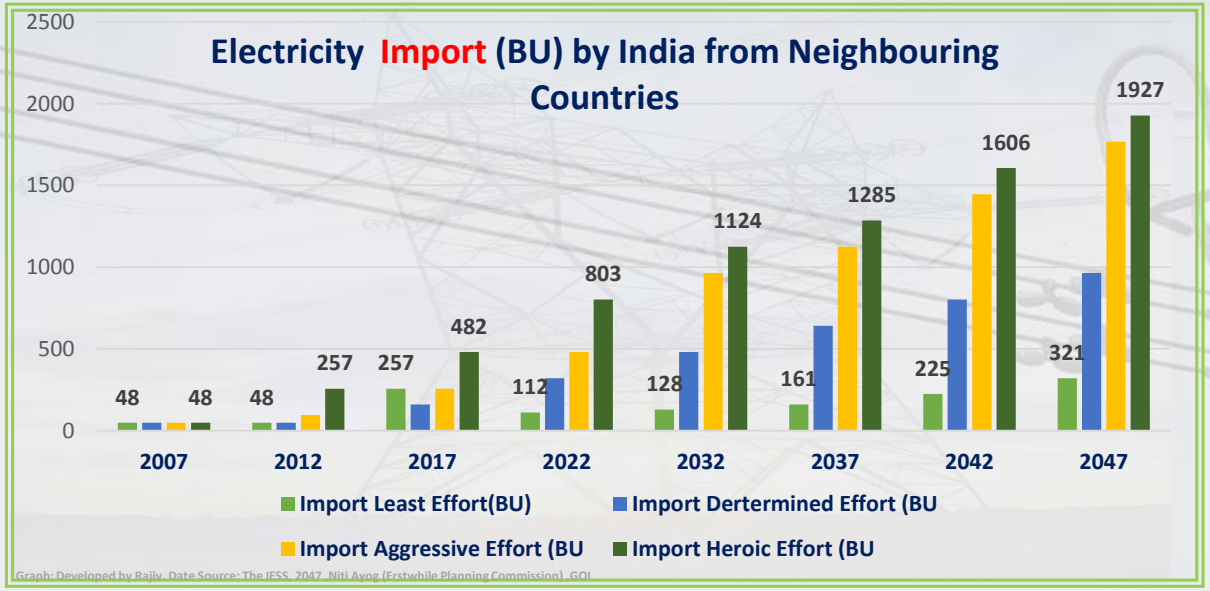

**Significant Transmission System Interconnection ( Both AC and DC) are being Planned and Proposed.**

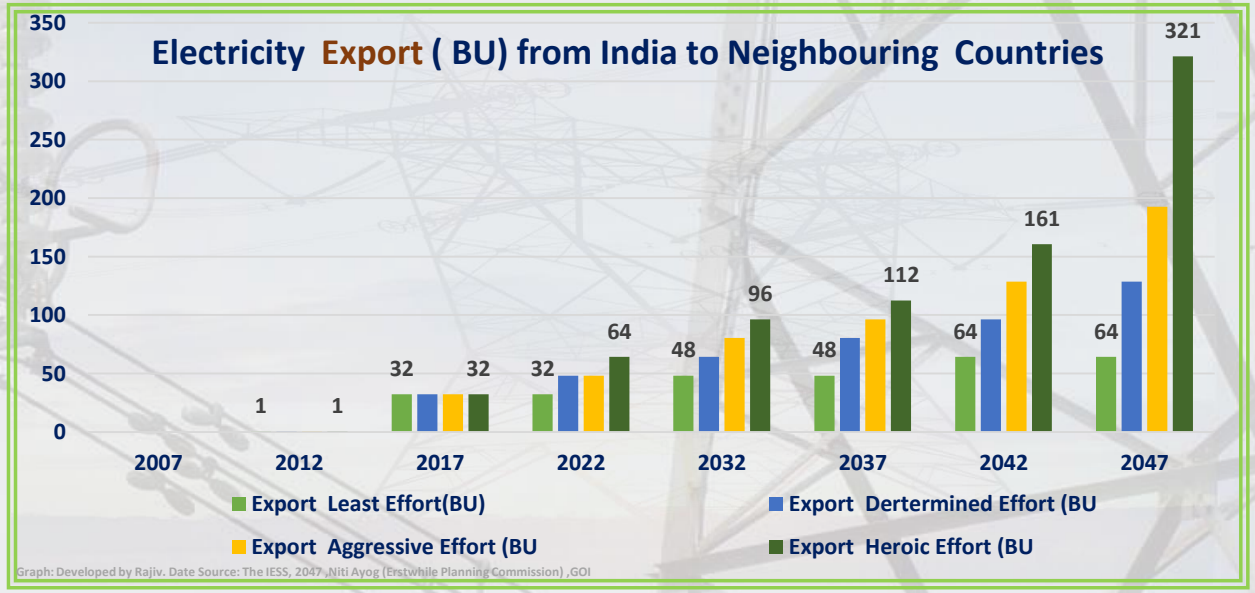
**Bangladesh is in the process of Planning to Import around Apprx. 6000 MW by 2034** (PMSP 2015-JICA Presentation,4th June,2015)

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




**Source: The IESS, 2047 ,Niti Ayog (Erstwhile Planning Commission) ,GOI**

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

- With Such 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 adjustment of differences & inconsistencies among measurements, methods, procedures, schedules, specifications of systems to make them uniform or mutually compatible.
- 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.

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# Scope of Work : Objectives

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# 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.

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# 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 5$^{th}$ 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

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# Status Update

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

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# South Asia Grid codes : gap Analysis

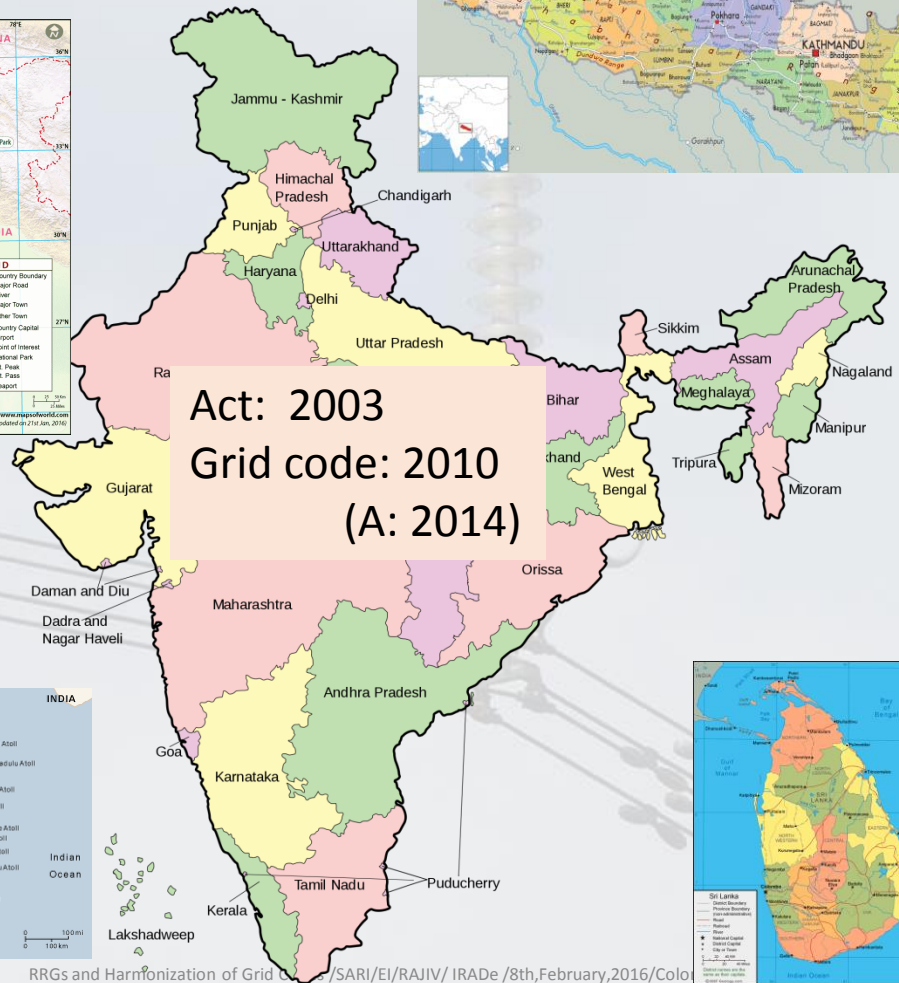

Act: NA
Grid code: NA

Act: 1992
Grid code: 2005



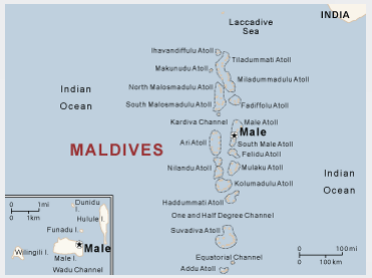
Act: 2001
Grid code: 2008


Act: NA
Grid code: 2005




Act: 2003
Grid code: 2010
(A: 2014)

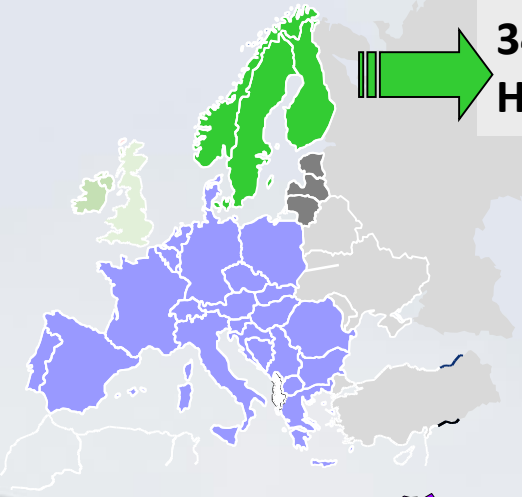

Act: 1910 (A: 2012)
Grid code: 2012




Act: NA
Grid code: NA

Act: 2009
Grid code: 2014

# International Experience Review and Impact Analysis



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

network codes

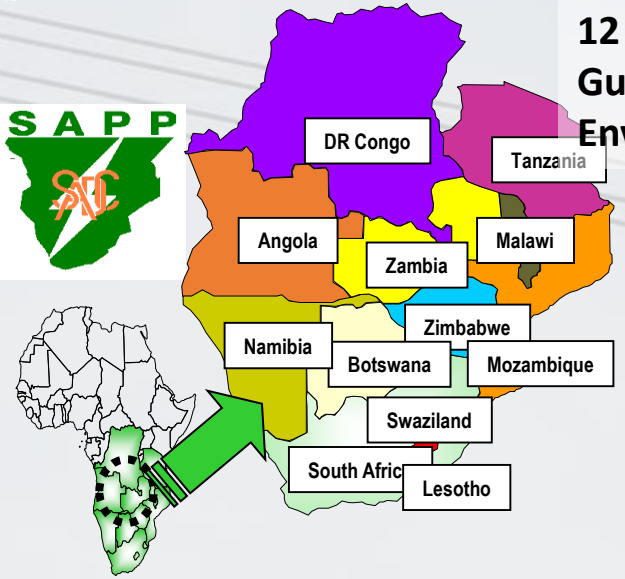
**Connection, Operational (Operational Security , Planning ,Scheduling ,L/F Control & Reserve),Market Codes( CA and Congestion Management, Electricity Balancing)**

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

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**

SAPP




**12 Countries:**
**Guidelines on Operation ,Planning and Environment**

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

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# Framework Guidelines

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# 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 is comprehensive in nature and 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.**

# Consultations with Stakeholders

## Discussion in TF meeting in Delhi and Kolkatta

The gap analysis was discussed with the members of Task force

## Discussion with Bhutan officials

The salient features of Harmonization of grid code along with Framework guidelines were presented and discussed with BEA, BPC and BPSO

## Discussion with Bangladesh officials

The Salient features of Harmonization of Grid code along with Framework guidelines discussed with NLDC and PGCB

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# Draft Framework Guidelines

# 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

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# Planning Guidelines

# Planning Guidelines: Objective & Applicability

## OBJECTIVE

- To specify the principles, procedures and criteria which shall be used in the planning and development of the cross border interconnections,
- To promote co-ordination amongst all participants in any proposed development of the cross border interconnections,
- To provide methodology and information exchange amongst participants in the planning and development of the cross border interconnections;

## APPLICABILITY

- Planning guidelines shall apply to Planning agencies, Transmission utilities and other entities involved in the developing or using of the cross border interconnections.

# Planning Guidelines: Planning Philosophy

The Master Plan shall form basis for the planning the interconnected network among member countries.

The Master Plan shall be formulated with the planning horizon of at least 10 years and reviewed every alternative year.

All the stakeholders shall furnish the desired planning data from time to time to enable to formulate and finalize plan.

As the cross-border interconnection is expected to cater for the long term requirements of member countries, sufficient forecasting of demand and generation 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 (for Light Load scenario, motor load of pumped storage plants shall be considered)

Reactive power plays a critical role in EHV transmission system management and hence forecast of reactive power demand on a system-wide basis is as important as active power forecast.

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.

# 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.

Note: For existing 220 kV and 132 kV cross-border lines, all criteria shall be with respect to the country grid code.

# 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 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 (FSC),
  - Outage of an Inter-Connecting Transformer (ICT),
  - 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.

# Planning Guidelines: Planning Margins

The new transmission additions required for cross-border transmission may be planned keeping a margin of 15% in the thermal loading limits of lines and transformers.

At the planning stage, a margin of about ±3% may be kept in the voltage limits and thus the voltages under load flow studies (for 'N-0' and 'N-1' steady-state conditions only) may be maintained within the limits given below:

- For 765 kV level, a maximum of 788 kV and a minimum of 742 kV
- For 500 kV level, a maximum of 515 kV and a minimum of 485 kV
- For 400 kV level, a maximum of 412 kV and a minimum of 388 kV

In planning studies all the transformers may be kept at nominal taps and On Load Tap Changer (OLTC) may not be considered. The effect of the taps shall be kept as operational margin

For the purpose of load flow studies at planning stage, the nuclear generating units shall normally not run at leading power factor. To keep some margin at planning stage, the reactive power limits (Qmax and Qmin) for generator buses may be taken as:

- Thermal Units: Qmax = 40% of Pmax, and Qmin = (-) 10% of Pmax
- Nuclear Units: Qmax = 40% of Pmax, and Qmin = (-) 0% of Pmax
- Hydro Units: Qmax = 50% of Pmax, and Qmin = (-) 20% of Pmax

# Planning Guidelines: Additional Planning Guidelines

## Reactive power compensation Studies

- Requirement of reactive power compensation (static and/or dynamic) shall be assessed through appropriate studies for cross border transactions. This compensation shall be provided by the respective entities within a country and import of reactive power shall be avoided to the extent possible.

## Cross-Border Sub-station planning criteria

- The maximum short-circuit level on any new substation bus shall not exceed 80% of the rated short circuit capacity of the substation equipment's.
- Rating of the various substation equipment's shall be such that they do not limit the loading limits of connected transmission lines.
- Effort shall be made to explore possibility of planning a new substation instead of adding transformer capacity at an existing substation. The maximum transformer capacity for different voltage levels shall be:
  - For 765 kV, 6000 MVA
  - For 500 kV & 400 kV, 1500 MVA
- While augmenting the transformation capacity at an existing substation or planning a new substation the fault level of the substation shall also be kept in view. If the fault level is low, the voltage stability studies shall be carried out.
- Size and number of interconnecting transformers (ICTs) shall be planned in such a way that the outage of any single unit would not over load the remaining ICT(s) or the underlying system.

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# Connection Guidelines

# Connection Guidelines: Objective & Applicability

## Objective

- Safe operation, integrity and reliability of the grid
- Basic rules for connectivity are complied with in order to treat all users in a non-discriminatory manner.
- Any new or modified connections, when established, shall neither suffer unacceptable effects due to its connectivity to the Inter-Transmission utility nor impose unacceptable effects on the system of any other connected User.
- Any person seeking a new connection to the grid is required to be aware, in advance, of the procedure for connectivity to the Inter-Transmission utility and also the standards and conditions his system has to meet for being integrated into the grid.

## Applicability

- Connection guidelines shall apply to all existing users and who are looking to connect for cross border connections.

# 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 compile with the connection code(s) the user shall capable to meet the minimum standard requirement at the interconnection point which is defined below :

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

# Connection Guidelines: Technical Requirements

## Reactive Power Requirements

- Respective country power authority need to ensure reactive power requirements is 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 limit by the respective transmission agencies to prevent mal-operation of the HVDC links.

## Data and Communication Facilities

- Reliable and efficient speech and data communication systems with adequate redundancy of communication links shall be provided to facilitate necessary communication and data exchange, and supervision/control of the cross-border interconnection by the respective System Operators in each of the country, under normal and abnormal conditions with defined time stamping.

## System Recording Instruments

- Recording instruments such as Data acquisition / Disturbance recorder / Event logging facilities / Phasor monitoring units / Fault locator (including time synchronization equipment) shall be provided and maintained in working condition by the user.

# Connection Guidelines: Technical Requirements

## Responsibilities for safety

- The concerned transmission asset owners shall ensure that all safety requirements for equipment and personnel as specified in the relevant technical standards of the concerned member country are fully complied with at all times.

## Cyber Security

- All member countries shall have in place, a cyber-security framework to identify the critical cyber assets and protect them so as to support reliable operation of the grid.

## Schedule of assets of Grid

- Maintenance activities shall be carried out by relevant owner/operator of the member country system. The concerned national transmission utilities shall mutually decide the maintenance procedure and time and coordinate the maintenance activity to minimize outage time at initial stage. In long term the independent authority or coordination forum can be identified to monitor and permit the outage. The designated transmission agencies are only authorized to carry out the maintenance work.

# Connection Guidelines: Additional Connection Guidelines

## Frequency

- User shall be capable of automatic disconnection at specified frequencies if required by the relevant operator / stay connected to the network and operating within the Frequency ranges and time periods which is specified by the system operator.
- Recommended frequency band of operation shall be within 49.9 Hz to 50.05 Hz but all the connecting equipment shall withstand the frequency profile as in Table .
- Frequency limits for equipments

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

# Connection Guidelines: Additional Connection Guidelines

## Voltage

- In accordance with their grid code at the connection point, within the legal framework approved by the relevant concerned authority the user shall ensure connection to the network does not result in a level of distortion or fluctuation of the supply voltage on the network
- In case of a deviation of the Network Voltage from its nominal value, the user equipment is capable of withstanding the voltage range and shall be capable of automatic disconnection beyond the voltages limits, if required by the respective system operator
- At the point of Interconnection, acceptable range of operating voltages shall be ±5% for 400 kV and above transmission voltage levels but all the connected equipment shall withstand the voltage variation of ±10%.

## Short-Circuit Fault Levels

- The coordination forum or the planning committee (as per planning guidelines) shall model the entire transmission system and provide minimum and maximum short circuit level of the interconnecting substation of cross-border link for various possible scenarios and the same shall be communicated to the respective designated transmission agencies.

# Connection Guidelines: Protection and Control

All necessary protection and backup protection equipment's shall be installed within the system in order to automatically prevent disturbance propagation which can endanger the operational security of the interconnected transmission system.

Maintenance and testing shall include:

- Maintenance and testing intervals and their basis.
- Summary of maintenance and testing procedures.

Each transmission owner and generator owner required to install **Disturbance Monitoring** Equipment's (DMEs) within the observability area that meets the following requirements

- Internal clocks in DME devices shall be synchronized to within 2 milliseconds or less of common time scale like Indian standard time scale (IST)
- Recorded data from each disturbance shall be retrievable up to ten calendar days.

# Connection Guidelines: Protection Requirements

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

Requirement 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 | |

# Connection Guidelines: Protection Requirements

## Requirements for Demand Facilities: Protection scheme devices may cover the following aspects:

- 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.

## Requirements for Transmission Owner

- Each transmission owner shall provide fault recording capability for the following elements : All transmission lines; Autotransformers or phase-shifters connected to busses; Shunt capacitors, shunt reactors; Individual generator line interconnections; Dynamic VAR devices; HVDC terminals
- Each transmission owner and generator owner shall provide fault recording with the following capabilities: Each fault recorder's record duration shall be a minimum of one (1) second ; shall have a minimum recording rate of 16 samples per cycle; Document additional triggers and deviations from the settings when local conditions dictate

# Connection Guidelines: Protection Requirements

## Requirements for Transmission Owner

- Each member country's transmission company shall establish its area requirements for Dynamic Disturbance Recording (DDR) capability that records dynamic disturbance information at major load centres, major generation facilities, major voltage sensitive areas and major transmission interfaces.
- They shall establish the requirements such that the following quantities are monitored or derived where DDRs are installed:
  - Line currents for most lines such that normal line maintenance activities do not interfere with DDR functionality.
  - Bus voltages such that normal bus maintenance activities do not interfere with DDR functionality.
  - As a minimum, one phase current per monitored element and two phase-to-neutral voltages of different elements. One of the monitored voltages shall be of the same phase as the monitored current.
  - Frequency.
  - Real and reactive power.

# 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

The metering shall record the following: Bus voltage; Frequency; Active Power, Energy; Reactive Power; Current;  Any other facilities as agreed in the connection agreement.

For cross border activities, it is recommending the minimum standard of accuracy of meters shall comply with the latest IEC standards. 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.

Main and Check Meters: The minimum standard of accuracy of Meters shall be 0.1%

The accuracy class of all billing devices shall be accurate with in 0.2% of full scale.

# Connection Guidelines: Ownership and Location of Meters

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.

**Table: Location of Meters**

| S. No | Stages | Main meter | Check Meter | Standby meter |
|---|---|---|---|---|
| 1. | 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 |
| 2. | 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. |

# Connection Guidelines: Metering Requirements

## Installation, Operation, Testing and Maintenance of Meters

- In accordance with the connection agreement among all the member countries, the operation, testing and maintenance of all types of meters shall be carried out by the designated transmission agency of the country.

## Access to Meter

- The designated transmission agency shall give permission for the relevant authorities to install, testing, commissioning, reading and recording and maintenance of meters.

## Sealing of Meters

- Designated transmission licensee or generating company as observers, shall lock and seal the meter and tamper proof, with no possibility of any adjustments at site, except for a restricted clock operation.
- Seal of the energy meter shall be removed only by the participating licensee who owns the meter, at the cross border

## Meter reading and recording

- Meter reading and recording functions shall be carried out by coordinating forum or the planning committee (as per planning guidelines) or separate agency as required.
- Any generation unit participating in the Energy Market is required to have independent metering devices that are capable of recording generation net MWh output.

# Connection Guidelines: Metering Requirements

## Safety of Meter

- The concerned user shall be responsible to take precautions for the safety of the energy meter installed in his premises belonging to the generating company or the licensee.

## METER FAILURES OR DISCREPANCIES

- Whenever difference between the readings of the Main meter and the Check meter is more than 0.5%, the following steps shall be taken in accordance with their grid codes
- In case of conspicuous failures like burning of meter and erratic display of metered parameters the meter shall be immediately replaced with a correct meter.
- Billing for the Failure period shall be done as per the procedure laid down by the Appropriate Commission.
- The meters shall be provided with anti-tampering features as per the Standards given in the schedule

## ADDITIONAL REQUIREMENTS FOR METERS

- The designated transmission agency shall take responsibility to test , calibrate and shall maintain the equipment to work within the prescribed limits.
- All new or replacement metering equipment shall be tested and calibrated annually as per prevailing IEC standards in the member country, jointly by the concerned agencies. The cost of testing/calibration of the energy meters shall be borne by the respective owner of the metering equipment.

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# Operational Guidelines

# Operational Guidelines: Objective & Applicability

## Objective

- To ensure secure system operation and scheduled power flow of the cross border link by the system operator of each of the member country following applicable rules.
- To establish design and documentation requirements for automatic under frequency load shedding programs to arrest declining frequency, assist recovery of frequency following under frequency events and provide last resort system preservation measures.
- Provide system preservation measures in an attempt to prevent system voltage collapse or voltage instability by implementing an under-voltage load shedding program.
- To ensure system protection is coordinated among operating entities.
- To ensure that all special protection systems are properly designed, meet performance requirements and are coordinated with other protection systems.
- To ensure that maintenance and testing programs are developed and mal-operations are analyzed and corrected.

## Applicability

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

# Operational Guidelines: System Security Aspects

In case of opening/removal of any important element of the grid under an emergency situation, the same shall be communicated to all affected entities at the earliest possible time after the event. The reason (to the extent determined) and the likely time of restoration shall also be intimated. All reasonable attempts shall be made for the elements' restoration as soon as possible.

The list of such important grid elements on which the above stipulations apply 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.

# Operational Guidelines: System Security Aspects

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. Such outages shall be reported to the other regional heads and restoration plans of such elements shall be taken up within a specified time period.

For each element in its transmission system, the operator shall define operational security limits. Based on these limits, the operator shall classify the current operating condition of its transmission system under one of the following five states in real time:

- Normal State
- Alert State
- Emergency State
- Black Out State
- Restoration

The determination of the system operation state shall be done continuously by monitoring the parameters against pre-set criteria and performing contingency analysis in real time if required.

All thermal and hydro generating units shall follow their respective Grid codes and shall be equipped with tuned PSS for effective damping of oscillations. All units shall have their AVRs in operation. Provision of protections and relay settings shall be coordinated periodically.

# Operational Guidelines: System Security Aspects

Adequate operating reserves (Primary/Secondary/Tertiary) shall be made available for use during contingency conditions and large demand variation conditions in case of synchronous interconnection. 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.

Each regional head shall provide and maintain adequate and reliable communication facility internally and with other heads to ensure exchange of data/information necessary to maintain reliability and security of the grid. Wherever possible, redundancy and alternate path shall be maintained for communication along important routes.

The system security limits shall be fixed as shown in Table

| | Normal | Alert | Emergency |
|---|---|---|---|
| **Voltage (400, 500 & 765 kV)** | ± 5% | ± 5% | ± 10% |
| **Frequency – for synchronously interconnected system** | Nominal: 50Hz<br>Steady state limits: +0.05Hz to -0.1Hz<br>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 |

# Operational Guidelines: System Security Aspects

In the initial development process, it is recommended to plan for special protection system (SPS) to prevent cascading with the outages and shall be used to analyze any unacceptable consequence is anticipated.

The functionality and system state status have to be monitored, communicated and coordinated between neighboring operator and other parties affected by the system protection.

The ancillary services required for maintaining and dispatching reserves with the help of governor/ primary response, secondary response/ tertiary reserves, contingency reserves and load shedding contract shall be defined

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.

If the impact is outside of its own responsibility area, each operator shall assess whether the protection system in its area worked as planned and shall undertake corrective actions if necessary.

Protection shall be operated with set-points that ensure reliable, fast and selective fault clearing, including backup protection for fault clearing in case of malfunction of the main protection system.

# Operational Guidelines: Criteria for Protection Set-Points

Protective relay settings shall not limit transmission loadability, not interfere with system operators' ability to take remedial action to protect system reliability and, be set to reliably detect all fault conditions and protect the electrical network from these faults.

Each transmission owner, generator owner, and distribution provider shall set its out-of-step blocking elements to allow tripping of phase protective relays for faults that occur during the loading conditions used to verify transmission line relay loadability.

Each transmission owner, generator owner, and distribution provider that sets transmission line relays within the vicinity of observable area shall provide an updated list of the circuits associated with those relays to its regional entity at least once each calendar year, to allow the compilation of a list of all circuits that have protective relay settings that limit circuit capability.

Any changes to the protection schemes, relevant for the demand facility and the network, as well as to the setting relevant for the demand facility, shall be agreed between the relevant operator and the transmission connected demand facility owner.

# 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 andis 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- Operational Liaison

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.

# 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- Outage Planning

In case of emergency in the system, viz., loss of generation, break down of transmission line affecting the system, grid disturbances, system isolation, the studies may be conducted again before clearance of the planned outage.

Annual outage plan shall be prepared in advance for the financial year taking into account the available resources in an optimal manner and shall be reviewed on quarterly and monthly basis in coordination with all parties concerned and reviewed, If any deviation is required the same shall be accommodated with prior permission of concerned authorities.

# Operation- Recovery Procedure

Any tripping, either manual or automatic, shall be communicated immediately by the System Operator detecting such event to their counterpart in the other country.

Detailed plans and procedures for restoration of the grid under (after) partial/total blackout shall be developed and reviewed / updated annually.

Mock trial runs of the procedure for different subsystems shall be carried out by the users at least once every six months.

List of generating stations with black start facility, inter-country ties, synchronizing points and essential loads to be restored on priority, shall be prepared.

Respective system operator shall coordinate the frequency management within a synchronous area. A common entity shall be appointed as the resynchronization leader who shall be responsible for coordinating with the regional heads during the resynchronization process of two neighbouring areas.

# Operation- Recovery Procedure

During the re-energizing processes, following considerations are taken into account:

- Each operator has to develop proper re-energisation procedures, at least by simulation or offline calculations.
- Each operator has to evaluate the number of units capable of black start and islanded operation to contribute to the restoration and to get knowledge of units in house load operation.
- 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 $\pm$ 200 mHz under the coordination of the area's regional head.
- The operator shall reenergize the shed load when system frequency is not below 49.8 Hz, keeping a generation margin sufficient at least to cope with the next block of load to reenergize. The process of reenergizing customers shall be done stepwise in block loads of maximum size defined by the operator with respect to the load of his grid.
- The operator shall coordinate the reconnection of generators tripped due to abnormal frequency excursion.
- The resynchronization leader of the concerned areas and in collaboration with the two regional heads of their respective areas will apply the required actions in order to operate the resynchronization under the following criteria:
  - Both systems shall be in a stable state and both frequencies must be near to 50 Hz to resynchronize as securely as possible.
  - Use of 400 kV line(s) of high loadability
  - Make provisions for closing immediately a second line that is electrically close to the first line.
  - To choose, by preference, a line for synchronization not in the vicinity of large thermal units in operation

# Operation- Event Information

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 oral notifications may be backed up with appropriate written reports.

# Operation- Coordination Between System Operators

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.

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# 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

During Computation of the Available Transfer Capability (ATC) 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.

It is initially envisaged to begin with bilateral contracts, gain experience and gradually ramp up to allow procurement/sale of power through the Power Exchange(s) operating in India.

# Scheduling & Dispatch Guidelines: Demarcation of Responsibilities

System Operator of a member country shall

- 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.
- 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 regulate their generation and / or consumers' load so as to maintain their actual drawal from the cross border grid close to the planned schedule i.e. scheduled drawal from contracts through long – term access, medium –term and short –term open access arrangements.

# Scheduling & Dispatch Guidelines: Demarcation of Responsibilities

The member country entities shall ensure that their manual/ automatic demand management scheme acts to ensure that there is no over drawl when frequency is 49.5 Hz or below. When the 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 power generation/power injection generally according to the daily schedules advised to them by the system operator of respective country on the basis of the contracts/requisitions received.

The generating stations may be allowed to generate beyond the given schedule under deficit conditions as long as such deviations do not cause system parameters to deteriorate beyond permissible limits . When the frequency is higher than 50.2 Hz, the actual net injection shall not exceed the scheduled dispatch for that time block.

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.

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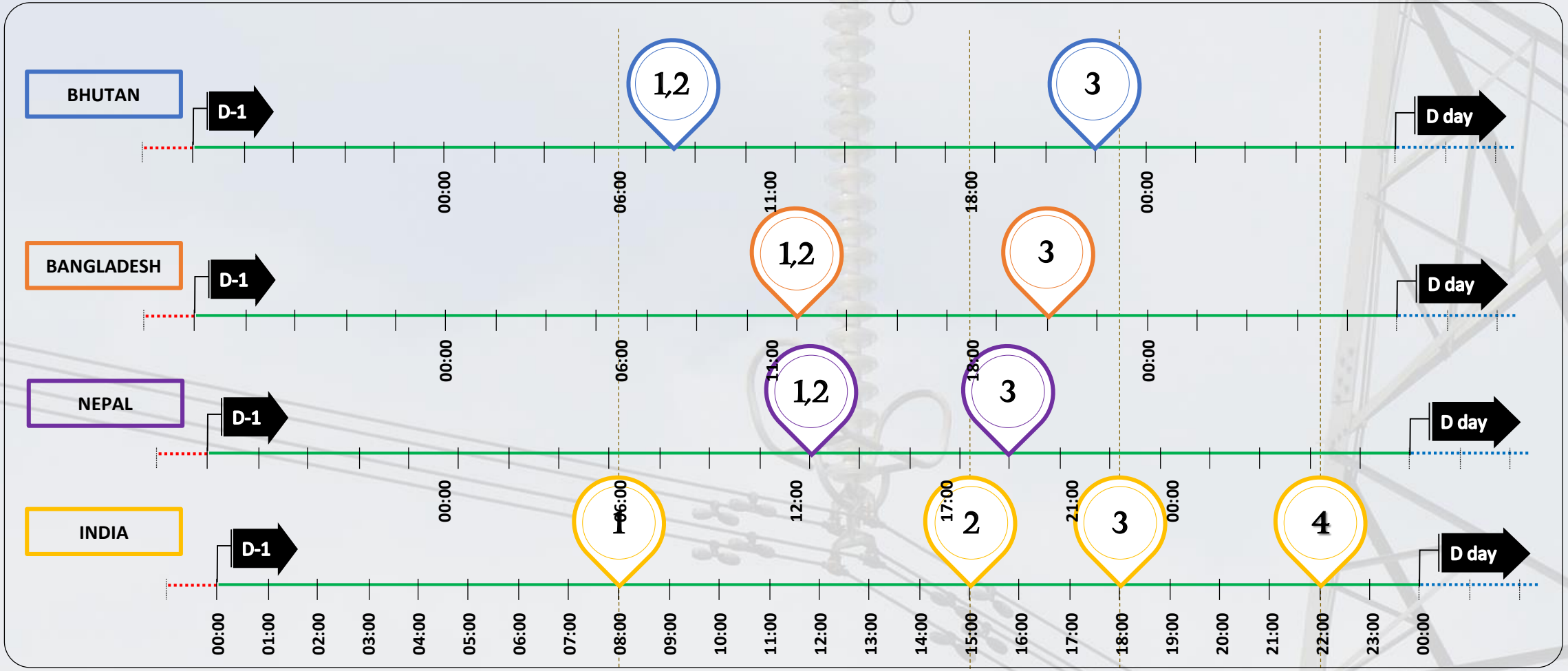
# Scheduling & Dispatch Guidelines: Timeline




**LEGEND**

1: Capability Declaration

2: Drawal Declaration

3: Drawl and Dispatch Schedule Finalization & Declaration

4: Last Call for Modifications

# Scheduling & Dispatch Guidelines: Deviation Settlement

Special energy meters shall install on 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.

To facilitate energy accounting, weekly meter readings shall be taken and transmitted to the respective system operators by Tuesday noon.

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: 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 following points shall be considered to calculate the Available Transfer Capability (ATC) :

- Capacity calculation timeframes (Long term, Short term, Intraday)
- Capacity calculation regions
- Common grid model methodology

The common grid model shall contain at least the following items:

- The generation and load data provision methodology
- A definition of possible scenarios
- A definition of individual grid models
- A description of the process for merging individual grid models to form the common grid model

The methodologies for the capacity calculation, which shall include the following parameters:

- A methodology for determining the reliability margin
- The methodologies for determining operational security limits, contingencies relevant to capacity calculation and allocation constraints that may be applied
- The methodology for determining remedial actions to be considered in capacity calculation

# Scheduling & Dispatch Guidelines: Congestion Management

Network congestion problems shall be addressed based on the secure and agreed market principles under the following circumstances:

- Grid voltage in the important nodes downstream/ upstream of the corridor is beyond the operating range
- The real time power flow along a corridor is such that N-1 contingency may not be satisfied.
- One or more transmission lines in the corridor are loaded beyond their normal limit

Whenever actual flow on the cross border links exceeds ATC and security criteria are violated a warning notice shall be issued. The notice for congestion shall be communicated to all the regional entities.

If the power flow on the interconnections is as per the schedule, but the congestion has been caused by forced outages of a transmission line, then open access transactions shall be curtailed as a last resort after exhausting all available remedial measures, followed by revision of TTC, TRM and ATC.

In consultation with all market players congestion charges shall be applied if violation of TTC limits persists for 2 time-blocks not counting the time-block in which warning notice was issued and no affirmative action is taken by the defaulting agency and would be levied for

- Over drawal or under-injection in the importing control area
- Under drawal or over-injection in the exporting control area.

Congestion charge shall be withdrawn after the power flow on the affected transmission link has come down to the ATC and remains at this level for one time block.

# 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.

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# 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:

- **Step 1:** 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.
- **Step 2:** 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 identify specific changes that are required in the national grid codes. While identifying such changes for modifying the grid code, they can adopt the proposed guidelines in Toto or in parts as appropriate.
- **Step 3:**
  - 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 framework guidelines and draft codes if needed.
- **Step 4:** 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.

# 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.

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# 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.

## 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

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# Critical Observations based on Meeting Stakeholders

The present grid code provisions are not strictly followed

There is a need for meeting of minds and capacity building with all systems operators of South Asian region to appraise of the grid code and Framework guidelines for CBET

The meetings of minds is also recommended for system planners

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# Thank You

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# Discussion