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

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4th PSC Meeting of SARI/EI
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Mumbai, India

Presentation Outline

- Back Ground
- Scope of Work
- Status Update
- Project Methodology
- International experience Review and Impact Analysis
- Some of the Key Massages/Findings so far:
- Way Forward: Overall Approach for Grid Code Harmonization/Coordination and Development of Framework Guidelines.

Background

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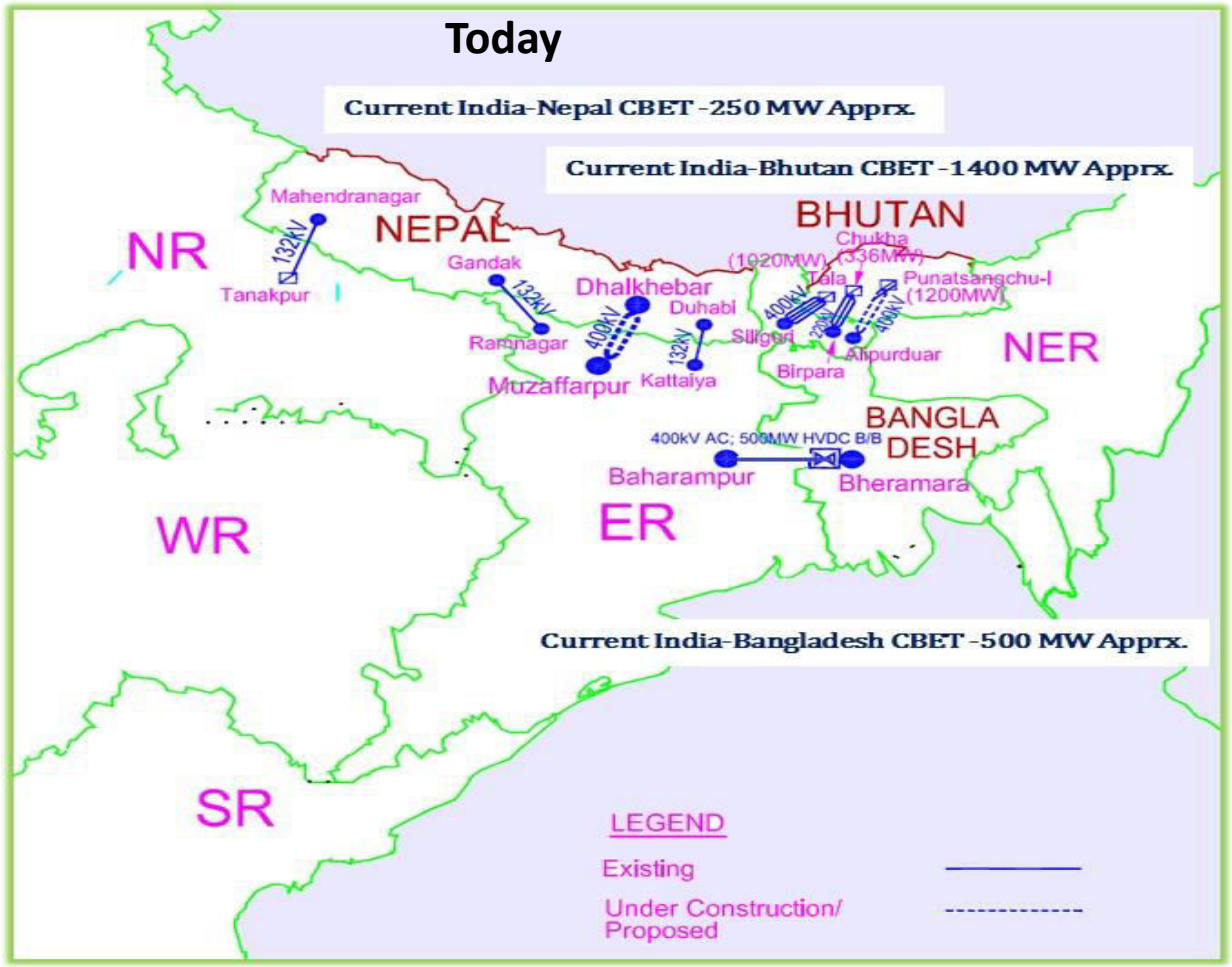
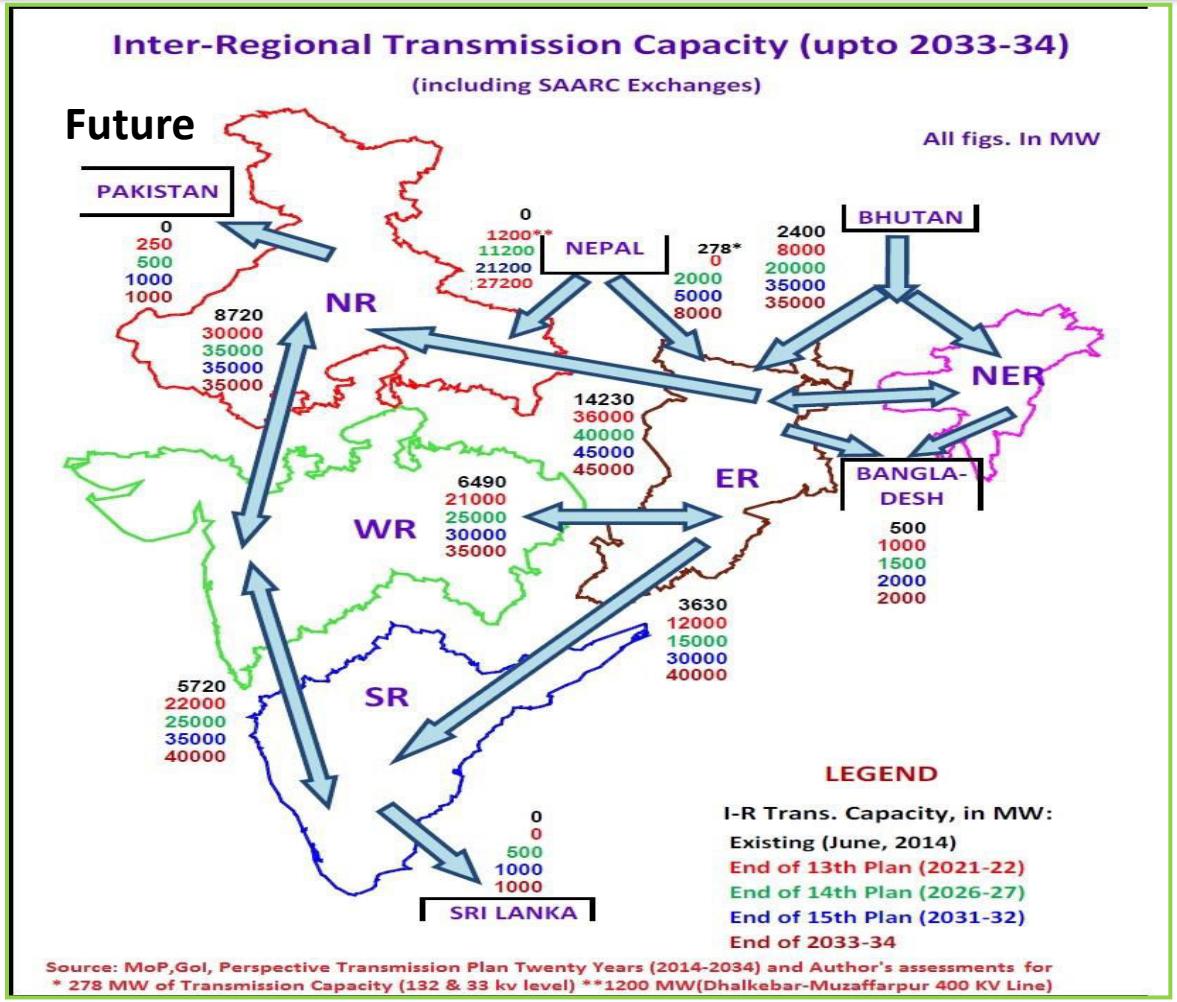
Background

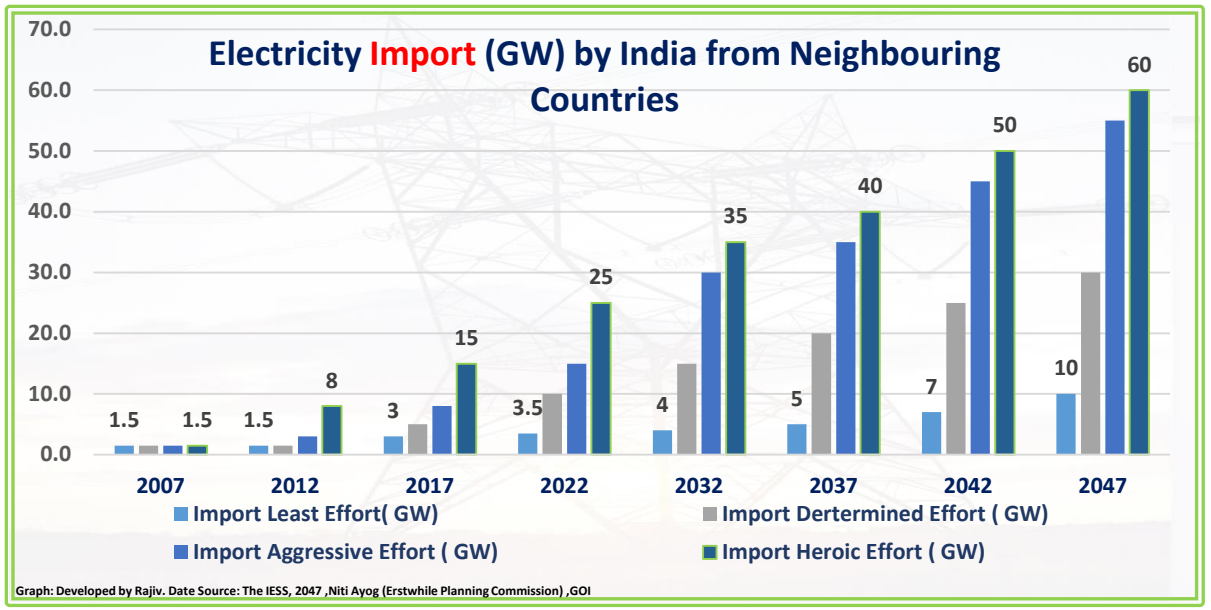


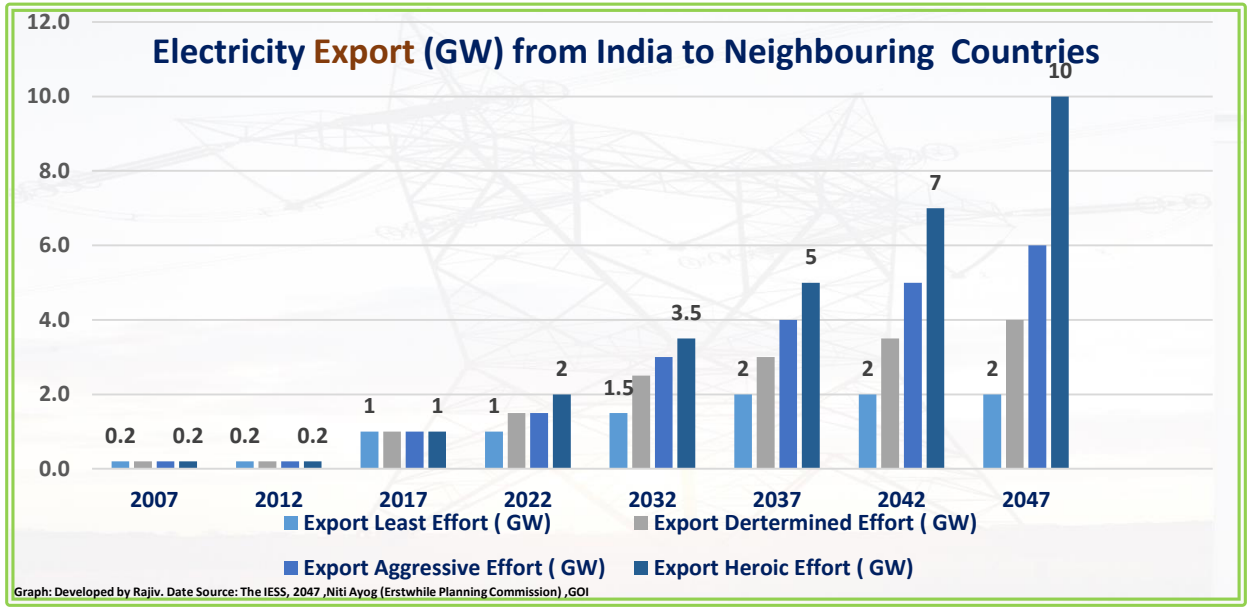


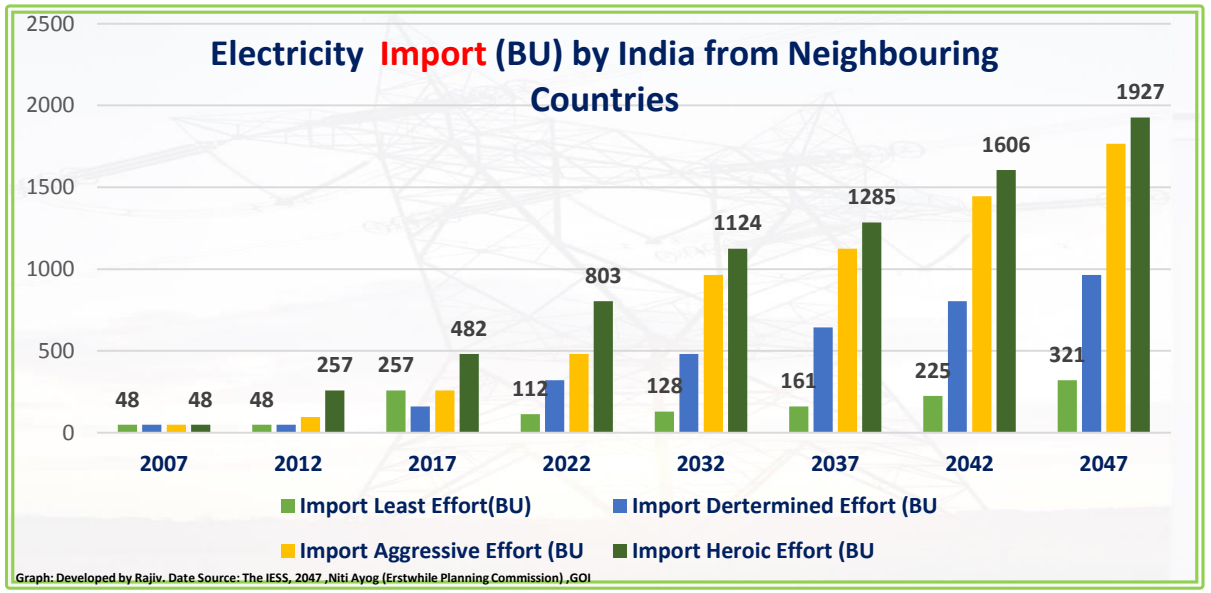
Significant Transmission System Interconnection (Both AC and DC) are being Planned and Proposed.

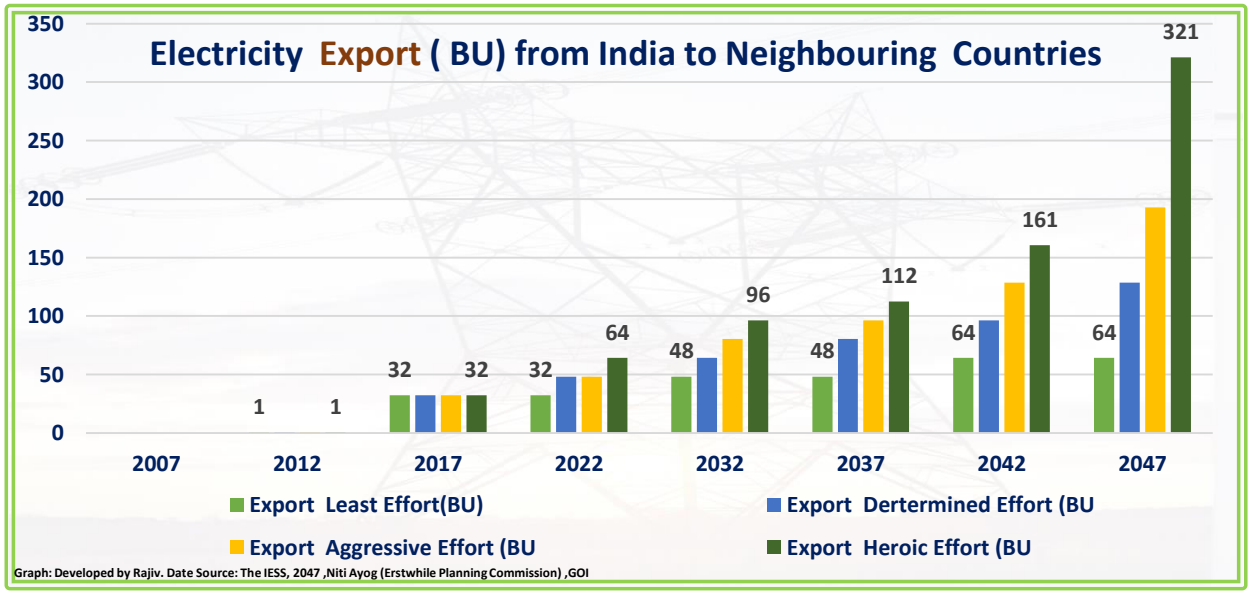
Bangladesh is in the process of Planning to Import around Apprx. 6000 MW by 2034 (PMSP 2015-JICA Presentation,4th June,2015)

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 ensured 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.

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.

Status Update

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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

- M/s PRDC,Bangalore is the conducting the study.
- 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.
- It was suggested that to carry out an international best practice review on the critical regulations related to grid code based on the similar cross-country power system and Impact Analysis of Grid Codes & Operating Procedures with respect to the International Review.
- International best practices (European, NERC-North American Electric Reliability Corporation,SAPP) and Impact Analysis of Grid Codes & Operating Procedures has been analysed and reviewed.
- Need to develop comprehensive framework guidelines along with Draft Codes (Is under progress)

Study Methodology

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

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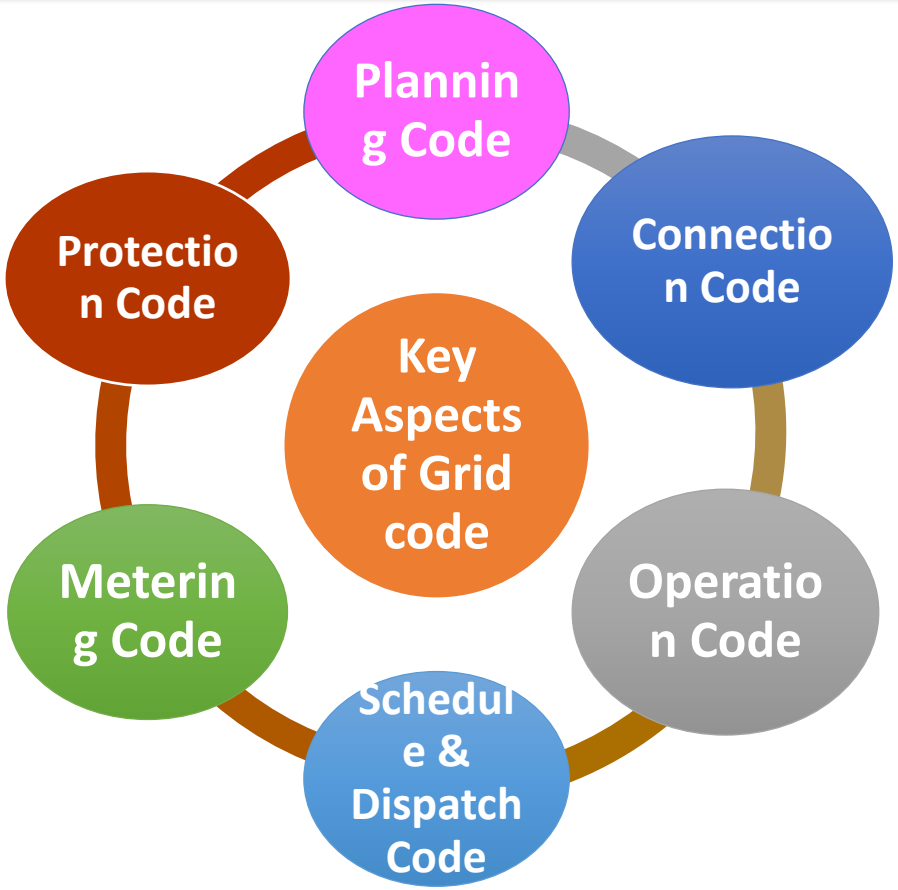
Review and Analysis of Grid Codes -Gap analysis

- Grid Code details the rules, procedures, guidelines, criteria and responsibilities to be complied with by the users, owners and operators of the transmission system of a country.
- Grid codes are approved by a regulatory body or government in exercise of powers conferred to it under the relevant electricity act/legislation
- Review of Grid Codes Gap analysis was carried out across six key aspect of grid code i.e. Planning , Connection, Operation ,Metering ,Protection and scheduling & despatch.



For interconnecting two grid systems, underlying principles of individual systems planning and operational framework has to be understood and harmonise the relevant rules in a limited manner purely for purpose of facilitating cross border interconnection and trading only.

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Grid Codes, Regulatory Institutional Framework Reviewed

Country	Grid code document	Electricity Sector Regulator
Afghanistan	NA	
Bangladesh	Grid Code, 2012	Bangladesh Electricity Regulatory Commission (BERC)
Bhutan	Grid Code 2008 (Reprint 2011)	Bhutan Electricity Authority (BEA)
India	Grid code 2010 (Amendment 2014)	Central Electricity Regulatory Commission (CERC) , State Electricity Regulatory Commissions (SERC) for each state
Maldives	NA	Maldives Energy Authority
Nepal	NA Grid code 2005	Department of Electricity Development
Pakistan	Grid Code, 2005	National Electric Power Regulatory Authority (NEPRA)
Sri Lanka	Grid Code, 2014	Public Utilities Commission (PUC)

Review of Grid Codes - Gap analysis : Key Summary on Planning Code

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Review of Grid Codes -Gap analysis : Key Summary on Planning Code

Planning code specifies

- The data information to be provided by all entities and various criteria to be adopted for Grid Planning
- Planning responsibilities of various entities in electricity sector.

Activity	Responsibility Authority	Country
Transmission planning activities	Transmission Licensee	Bhutan (BPC), Bangladesh (PGCB), India- (CEA/CTU/STU), Pakistan (NTDC), Sri Lanka (CEB)
	Grid owner	Nepal
Generation and Transmission Perspective Plan	Transmission Licensee	Pakistan, Sri Lanka, Nepal
	System Planner & transmission licensee	Bangladesh
	Ministry & System Operator (Dept. of hydro power & power system)	Bhutan
	CEA	India
Information Confidentiality	India: Nodal agencies shall provide the information to the public through various means of communications including internet. Other SA countries : Confidentiality of the user information made available to licensee shall be maintained.	

System master plan for each Cross border link– Decadal Plan with phased implementation.

For CBET Planning : Respective Transmission Agencies plan /coordinated transmission planning/Planning Committee

Information confidentiality or available on Public Domain.

Review of Grid Codes -Gap analysis : Key Summary on Planning Code

Criteria	Country	Remarks
'N-1' contingency criteria for AC lines	All SA countries	In India, outage of single circuit at 400 kV and 765 kV levels and outage of double circuit at 132 kV and 220 kV levels is considered as 'N-1' outage whereas in other grid codes, at all transmission voltage levels, outage of single circuit is considered. N-2 criterion is applied to important load centres.
'N-1' contingency criteria for HVDC	India	**HVDC Back-to-Back Station or HVDC Bi-Pole line**
Dynamic Stability	All SA countries	**Among other SA nations, Bangladesh, India and Pakistan specify that system shall survive a permanent three phase to ground fault on EHV lines with a fault clearance time of 100 ms. India grid code specifies many other disturbances also in detail for system stability.**
Generator loss	India and Sri Lanka	**System shall survive the loss the largest/critical generating unit.**

Contingency criteria : In the synchronous interconnection, the criteria of N-1 or N-1-1 contingency shall be defined and adopted

Review of Grid Codes -Gap analysis : Key Summary on Planning Code

Except India, grid codes of all other SA nations specify the same voltage variation limits for both planning and operation stages. (For India: refer CEA's manual on transmission planning).

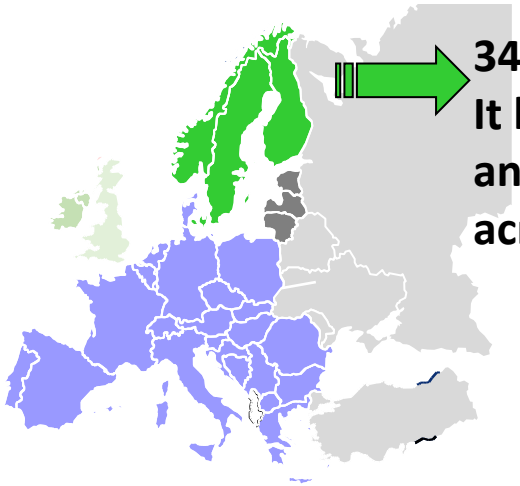
Country	Voltage – Normal		Voltage - Emergency conditions
	Planning Studies	Operational conditions	
Nepal,Bhutan ,Bangladesh	+/- 5%	+/- 5%	+/- 10%
Sri Lanka	+/- 5% for 132 kV, +/-10% for 220 kV	+/- 5% for 132 kV, +/-10% for 220 kV	+/- 10% for 132 kV, +/-10% for 220 kV
Pakistan	+/- 5% for 500 kV, 220 kV	+/- 5% for 500 kV, 220 kV	+/- 10% for 500 kV, 220 kV
India	+/- 2%→ 765 kV; +/- 3% → 400 kV; +/- 5% to 7% for below 220 kV	+/- 5% for 400 kV, 765 kV; +/- 10% for below 220 kV	+/- 5% for 400 kV, 765 kV; +/- 10% for below 220 kV

Voltage Deviations shall be in the same range for interconnection

For EHV (above 400kV) +/-5%

International experience Review and Impact Analysis

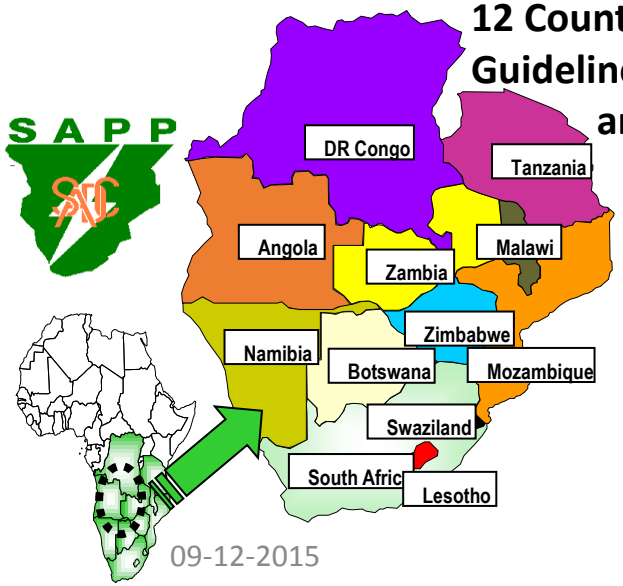
International Experience Review and Impact Analysis



34 European Countries : ENTSOe
It has Framework Guidelines(FG) and Based on FG Network codes across key areas: Connection, Operational (Operational Security , Planning ,Scheduling ,L/F Control & Reserve) Market Codes(CA and Congestion Management, Electricity Balancing)

NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico.

Various Standards related to Reliability Operation



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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Transmission Planning Process and Criteria

European Grid Code/ENTSOe.

- TSO is responsible for planning,Upto 30 years ahead planning term categorized as mid, long & very long term.
- Contingencies listed and classified as Normal, Exceptional and Out Of Range.
- All TSOs are obligated to serve under an 'N-1' principle which is developed with the goal of preventing propagation of an incident.

NERC-Regulations/Standards

- Planning coordinator performs resource adequacy analysis.
- Apart from following year, studies carried out for up to 10 years, categorized as near and long term.
- Contingencies are classified as Normal, events resulting in single element loss, events resulting in multiple elements loss, extreme events resulting in single element removal or cascading outage.

SAPP Rules/Criteria, Grid Code

- Utility publishes the 5 year ahead Transmission System.
- Normal and N-1 contingency studies performed to assess reliability.
- Individual members develop criteria ensuring system security and reactive compensation.

South Asian Countries' Grid Code

- Either a planning authority or the operator prepares the plan.
- Different time horizon followed by different countries ranging from 1 to 20 years.
- Normal and N-1 contingencies are applicable. N-1-1 also included in India. LFA, SCS, TRS studies are used for planning.

Recommendations:

1. It is critical to have a coordinating institutional mechanism.
2. Road map with Master Plan covering the next 10 years .
3. System modelling and running studies for security assessment and Contingency studies for both Asynchronous and Synchronous connections.

Some of the Key Massages/Findings so far based Review of South Asian grid Code, International experience and Impact Analysis.

1. Recommended Frequency band of operation of synchronised interconnection shall be within 49.9 Hz to 50.05 Hz.
2. All the connecting equipment shall withstand the 49 to 51 Hz and for limited duration beyond the specified limits.
3. At the point of Interconnection, acceptable range of operating voltages shall be ± 5% for 400 kV and above transmission voltage levels.
4. All the connected equipment shall withstand the voltage variation of ±10%
5. Reactive Power: Participating generators must comply with respective country's regulation. Reactive power flow through cross border AC links shall be limited to 0.97 lead/lag at PCC. As for HVDC links, voltage shall remain within limits.
6. Accuracy Class of Meters: 0.2 Accuracy class and above Guidelines can be followed for SA Cross Border trade.
7. The scheduling block of 15 minutes duration is considered with Indian time as reference time
8. An observability area has been defined for system operators to see the neighboring grid and two levels beneath the interconnection point has been considered for applicability of connection guidelines.
9. Special protection mechanism to take care of deficiency in the system and single pole outage of HVDC links.

WAY FORWARD

Way Forward

International practices on cross border trading

- Impact analysis for cross border trade of SA countries considering International practices on border flows.

Formulation of Guidelines / harmonized Grid code for SA nations

- Guidelines /codes with reference to cross border trading while maintaining country specific grid codes for internal power system planning & operation.

Way Forward: 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

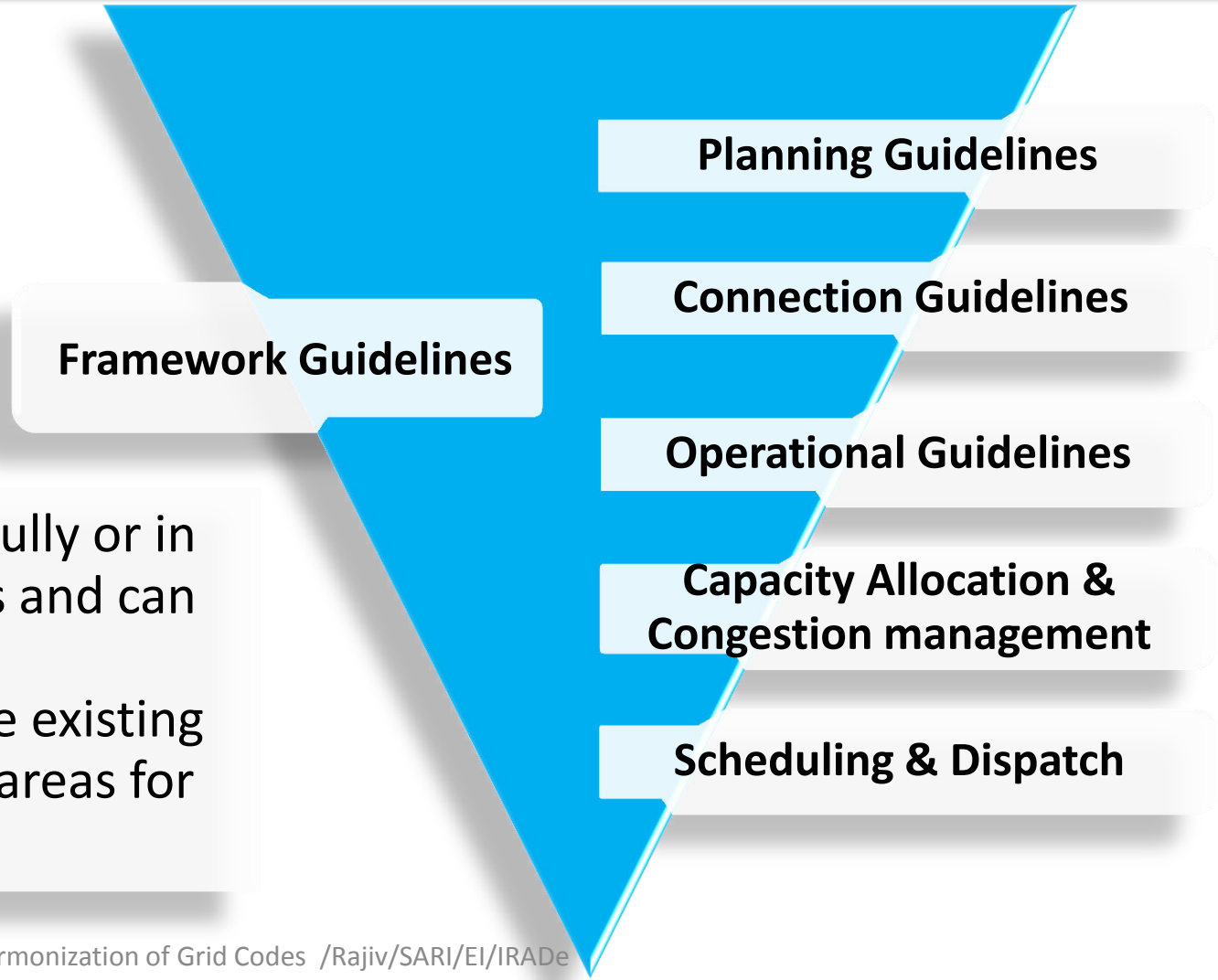
Development of Framework Guidelines

The Framework Guidelines will be comprehensive in nature and shall contain

- **Impact analysis**
- **Explanatory statement**
- **Implementation Provisions**
- **Draft code**

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.

Way Forward- Identified Areas for Framework Guidelines



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.

Way Forward- Identified Areas for Framework Guidelines and It's Linkage with SAARC Framework Agreement for Energy (Electricity) Cooperation (SFAEC)

The planning guidelines will be prepared in line with overall intent of the Article 7 of the SAARC Framework Agreement for Energy (Electricity) Cooperation (SFAEC).

The connection guidelines would be in line with the overall intent of the Article 8, Article 9 and Article 10 of the SFAEC.

The guideline on system operation and capacity allocation and congestion management will be prepared in line with overall intent of the article 11 and article 12 of SFAEC respectively.

SAARC
South Asian Association for Regional Cooperation

Framework Agreement for Energy (Electricity) Cooperation (SFAEC)

Guidelines for Planning Code

Master Plan shall be prepared for cross border trading considering 400 kV and above network between connected countries for next 10 or 20 years and revalidated every three year.

The master plan can be for bi-lateral transaction or multilateral transactions

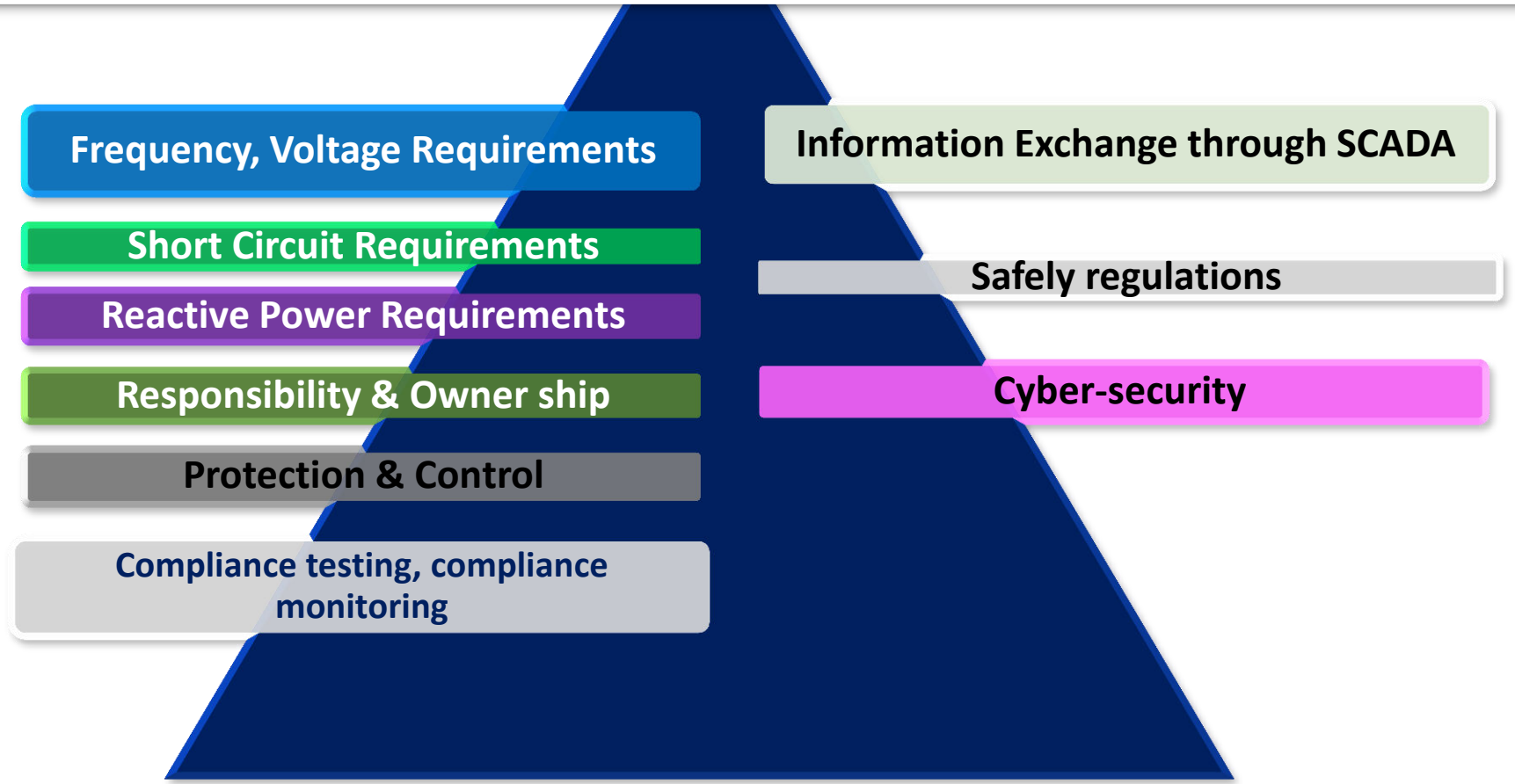
The master plan (both generation & Transmission) also shall include feasibility studies for future years with various possible scenarios.

The planning guidelines shall consider the following

- Transmission system capability of withstanding loss of most severe single system infeed
- Transient Stability Limits
- Accounting for renewables in planning
- Reactive Power planning

Framework Guidelines: Connection Guidelines

The following technical requirements shall be considered while making for cross border connection code



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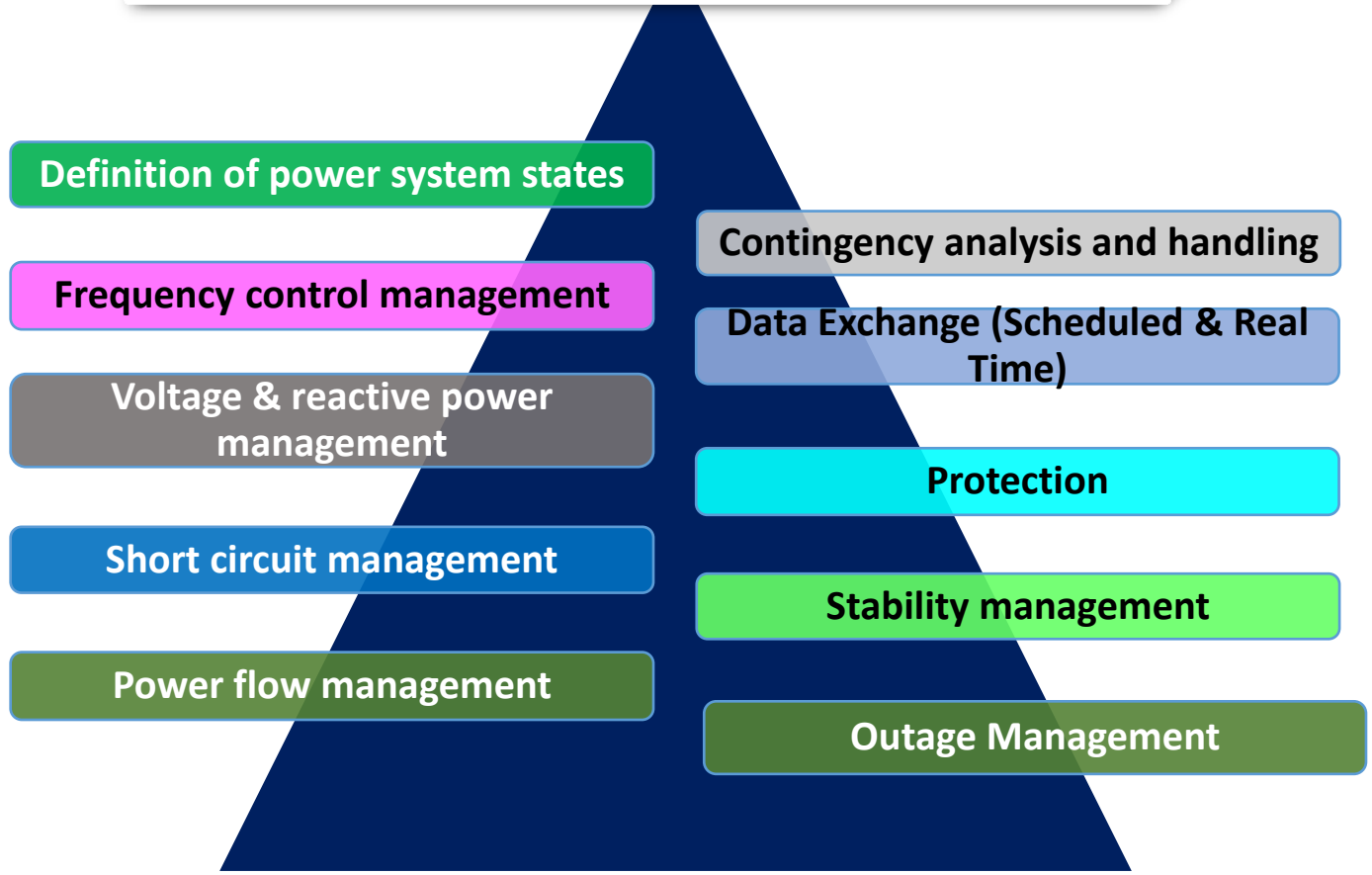
Way Forward: Operational Guidelines

The following aspects shall be considered while making guidelines for Operation of cross border trading.

- **Outage Planning (Annually/Monthly/Weekly)**
- **Operational Security Analysis**
- **Frequency control and handling of Reserves**
- **Emergency operational procedures**

The following technical aspects shall be considered while making for Operational Code



Way Forward: Capacity Allocation & Congestion Management

The following aspects shall be considered while making guidelines for cross border Capacity Allocation & Congestion management.

Each country shall provide ATC and TTC for specific cross border transmission paths for long term and short term trading.

Capacity calculation methodology considering reliability margin, contingency, local system changes etc.

Capacity allocations for day ahead and intra day operations

Congestion relieving mechanisms

Way Forward: Guidelines for scheduling & Dispatch

The following aspects shall be considered while making guidelines & Code for scheduling & Dispatch

- Establishment of scheduling processes
- Provision of information to other country system operators
- Day ahead scheduling procedure
- Intra day scheduling/revision procedure
- Sharing of information on schedules with other trading countries
- Standardized Scheduling intervals (15 min)

The commercial framework for Deviation settlement is not part of Technical guidelines

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Thank You

Technical Info

Country	Permissible Frequency Band (Hz)
Afghanistan	NA
Bangladesh	49.0 – 51.0 Hz
Bhutan	49.5 – 50.5 Hz
India	49.9 – 50.05 Hz
Maldives	49.5 – 50.5 Hz
Nepal	48.75 – 51.25 Hz
Pakistan	49.4 – 50.5 Hz
Sri Lanka	49.5 – 50.5 Hz

Country	Transmission Voltage Levels (kV)	Permissible Deviation
Afghanistan	220, 110	NA
Bangladesh	400, 230	+/- 5%
Bhutan	400, 220	+/- 5%
India	765, 400 220,	+/- 5%; +/-10%;
Maldives	33, 11	+/- 10%
Nepal	220, 132,	+/- 10%
Pakistan	500, 220	+/- 10%
Sri Lanka	220,132	+/- 5%; +/- 10%

Acceptable Voltage Deviations are similar but the permitted frequency deviation is different- Need to harmonize for synchronous Croos Border interconnection

Grid Code: Gap Analysis of SA countries

Gap Analysis of SA countries : Connection Code

Connection code specifies a minimum of technical, design and operational plant criteria to be complied with by the existing connected user and prospective users.

Activity	Responsible Authority	Country
Site Responsibility Schedule (SRS) for each connection point to be prepared by	Licensee	Bangladesh
	Transmission &Generation licensee	Bhutan
	Substation/Connection Site Owner	India
	Grid Owner	Nepal
	NTDC and Generation licensee	Pakistan
	transmission licensee and Users	Sri Lanka
Schedule of Transmission Assets: Submission of annual schedule of Assets to concerted authorities	Transmission License	

Transmission Licensee is responsible for SRS and Schedule

Transmission licensee in all SA countries and CTU in India ?

Gap Analysis of SA countries : Connection Code

Criteria	Country	Remarks
Reactive Power Compensation	All SA countries	All the grid codes specify that users shall not depend on the grid for reactive power and shall install facilities for maintaining power factor.
Generators shall be capable of operating at	Bangladesh	0.8 (lagging) to 0.95 (leading)
	India	0.9 (lagging) to 0.95 (leading)
	Nepal, Sri Lanka	0.85 (lagging) to 0.95 (leading)
	Pakistan	0.8 (lagging) to 0.9 (leading)
Distribution licensees shall maintain a power factor	India, Pakistan	within 0.95 at the connection point
	Nepal	within 0.8 (lagging) and 0.95 (leading)

Generators must comply with respective country regulation & Reactive power Limits only for AC interconnection

0.97 lead and lag at the point of interconnection within permissible voltage deviation

Gap Analysis of SA countries : Connection Code

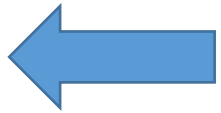
Criteria	Country	Remarks
Data Communication & System Recording Facilities	All SA countries	▪ All the grid codes specify that the users and licensees shall provide and maintain voice and data communication facilities. ▪ Grid codes of Bhutan, India and Pakistan specify recording instruments shall be provided by users and licensees
Cyber Security	India	All utilities in India 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
International Inter-connection	**Bhutan**	by Agency assigned by the Ministry
	Bangladesh	by the licensee in consultation with the Commission and Ministry
	India	by the CTU in consultation with the CEA and the Ministry.

Cyber Security, Data communication and system recording facilities be mandated ?

Gap Analysis of SA countries : Metering Code

Metering code specifies the type, standards, ownership, location, accuracy class etc. and responsibilities of the generating companies/licensees and transmission and distribution licensees.

Country	Metering type	Standards	Ownership
Bangladesh	Generation, Transmission & Distribution meters for operational & commercial metering.	Bangladesh Standards/ relevant IEC	Operation metering owned by Generator/Transmission licensee. Commercial metering owned by Transmission licensee.
Bhutan	Energy Meters for Accounting purposes	Bhutan Standard	Licensee in whose premises meter is present.
India	Interface meters, Consumer meters, Energy Accounting & audit meters. All are of static type.	BIS. If not then IEC/BS	Interface meters and Consumer meters owned by Transmission licensees. Energy Accounting & audit meters owned by generating company/licensee.



Gap Analysis of SA countries : Metering Code

Country	Metering type	Standards	Ownership
Nepal	Operational metering & Bi-directional Energy meters for accounting.	Relevant IEC	Generating plants and Grid owner shall own their respective meters.
Pakistan	Revenue Metering	Relevant IEC	Grid users shall install and Own the revenue meters.
Sri Lanka	Static Energy & Demand meters. Also, revenue metering if required.	Relevant IEC	Grid users supply the meters. Transmission licensee responsible for Installing and owning them.

All meters for interconnection shall be owned by govt. Transmission Licensee/CTU

Energy Accounting and Audit functions - Coordinating mechanism (i.e, Bi-lateral) or separate agency?

Gap Analysis of SA countries : Metering Code

All grid codes specify that Metering point shall be at point of interconnection wherever possible.

Grid codes of Bhutan, Pakistan & Sri Lanka specify energy meters for billing shall be

- At HV side of Generator transformer
- At LV side of Power transformers at Grid substations

Indian grid code specifies that

- Interface meters shall be provided on
  - Transmission interconnection points of open access customers for billing purposes.
  - all outgoing feeders at a generating station,
  - one end of lines between substations under same licensee, both sides of the line between substations of different licensees and HV side of ICTs.

Gap Analysis of SA countries : Metering Code

Accuracy Class of Meters	• **0.2 class - specified in all grid codes.**
Meter Data Processing	• **Provision to transfer the meter readings at transmission connection point to remote location through data communication channels.** • **Meter data is processed by respective system operators/responsible agencies.**
Access	• **All the grid codes specify that the owner of the premises where, the meter is installed shall provide access to the authorized representative(s) of the licensee for installation, testing, commissioning, reading and recording and maintenance of meters.**
Procedures for testing & calibration and to manage Meter failures & Discrepancies	• **specified in all the grid codes.**

0.2 Accuracy class and above Guidelines can be followed for SA Cross Border trade

Gap Analysis of SA countries : Protection Code

Protection code specifies criteria or standards to be complied with by the grid protection schemes & also specifies the responsibilities of the concerned entities.

Country	Authority to prepare & review protection plan	Ownership
Bangladesh	Transmission Licensee	Users & Transmission licensee
Bhutan	System Coordination Committee	Users & Transmission licensee
India	RPC Secretariat, Protection Coordination Sub-Committee	Users, Transmission licensees & System Operator
Nepal	Grid Owner (NEA)	Users & Grid owner
Pakistan	NTDC	Users & NTDC
Sri Lanka	Transmission Licensee (CEB)	Users & Transmission licensee

Respective agency can be vested to prepare and review protection plan or need for co-ordination forum?

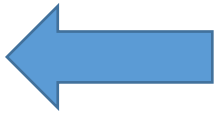
Gap Analysis of SA countries : Protection Code

Protection Scheme	Remarks
Back Up protection	Specified by all countries except Bhutan.
Circuit Breaker fail protection	Specified by all countries except Bhutan.
Bus Bar Protection	Specified by Bangladesh, India & Pakistan grid codes.
System Protection Schemes	Specified by only Bhutan & India grid codes. To protect from voltage collapse, cascade tripping and tripping of important corridors.
Generator protection	In India, all generators above 100 MW, shall have two independent sets of main protection schemes and a backup protection scheme. Other nations specify one main & one back up protection scheme.
Transmission Line protection	Each transmission line shall be provided with two sets of distance protection schemes and a backup scheme in Bangladesh, India & Pakistan. In Nepal, a minimum of one distance protection scheme and a backup scheme shall be provided. Sri Lanka & Bhutan do not specify transmission line protection scheme
Disturbance logging facilities	Disturbance recording & event logging facilities along with time synchronization facility for global common time reference shall be provided in India & Pakistan.

Gap Analysis of SA countries : Operation Code

Operating States:

- Only Bhutan grid code specifies the criteria for classifying an operating state as either Normal/Alert/Emergency.
- Pakistan grid code specifies 'N-1' contingency as emergency state.
- Other SA nations specify different security limits for Normal & Emergency conditions but they don't define the criteria for classifying "Emergency conditions".
- Indian grid code does not specify security limits for emergency conditions



	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
Voltage Variation	Normal: ±5% Emergency: ±10%	Normal: ±5% Alert: ±10%	Normal: ±5% for 400 kV, 765 kV ±10% for 220 kV & below.	Normal: ±5% Emergency: ±10%	Normal: 8% and -5% . Emergency: ±10%	Normal: ±5% for 132 kV, ±10% for 220 kV. Emergency: ±10%
Operating Frequency Variation	49 Hz to 51 Hz	Normal: 49.5 Hz to 50.5 Hz Alert: 49 Hz to 51Hz but above Normal range.	49.9 Hz to 50.05 Hz	48.75 – 51.25 Hz	49.8 Hz to 50.2 Hz	49.5 Hz to 50.5 Hz

Gap Analysis of SA countries : Operation Code

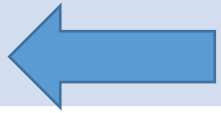
Operational Requirements of Generators

	Governor Action		AVR	PSS
Bangladesh	Yes. But Unit type, rating and droop details not given.	Free Governor Mode	Yes	-
Bhutan	Yes. Every Hydro unit above 10 MW. Droop: 3% to 10%.	Free Governor Mode	Yes. Every Hydro above 10 MW.	-
India	Yes. Every Thermal unit above 200 MW and Hydro above 10 MW. Droop: 3% to 6%. Dead band ± 0.03 Hz.	Restricted Governor Mode (no time delay allowed).	Yes. Every generator above 50 MW.	If installed, a plan prepared by CTU/RPC is followed for the tuning of the same.
Nepal	Only those units that form frequency regulating reserve.	Free Governor Mode	Yes	-
Pakistan	Yes. Every thermal unit above 100 MW and reservoir based generators.	Free Governor Mode	Yes.	-
Sri Lanka	Yes. Droop : 3% to 5%. Dead band ± 0.05 Hz.	Free Governor Mode	Yes.	-

Generators should follow the respective Operational Requirement of the Country of location

Gap Analysis of SA countries : Operation Code

Criteria	Country	Remarks
Generation Reserves	All SA nations except India	A part of installed generation capacity should constitute operational reserves
	India, Bhutan	All thermal generating units of 200 MW (India) and above and all hydro units of 10 MW and above (India & Bhutan) operating at or up to 100% of their Maximum Continuous Rating (MCR) shall be capable of instantaneously picking up to 105% and 110% of their MCR, respectively, when frequency falls suddenly.
Generation Ramping Up/Down rate	All SA nations	Ramping rate limits of the generator units should be considered while giving dispatch instructions to them.
	Bangladesh, Nepal	When frequency goes below 49 Hz/49.5 Hz or above 51 Hz/ 50.5 Hz, concerned generators shall ramp up/down at 2% per 0.1 Hz frequency deviation.
	Bhutan, India	The supplementary frequency control shall be 1% per minute or as per manufacturer's limits. However, during frequency going below 49.7 Hz, load pick-up shall be at a faster rate.



Gap Analysis of SA countries : Operation Code

Criteria	Country	Remarks
Special Requirements for Solar/Wind Generators	India	system operator shall treat Solar/Wind generators as “MUST RUN” stations and shall make all efforts to evacuate Solar & Wind power except when grid security/reliability is compromised.
Short term Demand Estimation for Operational Purposes	Bangladesh, Nepal, Pakistan , Sri Lanka	by Transmission licensees
	Bhutan	by System Operator and Distribution licensees
	India	Demand Forecast by SLDC’s Wind Energy Forecasting shall be considered while estimating the active and reactive power requirement.

Guide lines for activation of additional generation or reserves for changes in cross border flows

Gap Analysis of SA countries : Operation Code

Demand Management

Criteria	Country	Remarks
Demand Management	All SA countries	▪ System Operator & Distribution licensees shall provide arrangements for demand reduction during insufficient generating capacity/congestion/other operating problems. ▪ During under frequency conditions, the System Operator shall give demand control instructions to distribution licensees to reduce their drawl from the grid. ▪ India & Bhutan specify demand control during inadequate import from external interconnections too.

Respective authority needs to adhere to demand management control without effecting grid security

Gap Analysis of SA countries : Operation Code

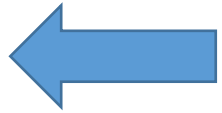
Criteria	Country	Remarks
Demand Management	India	▪ Indian Grid code specifies, during normal frequency conditions also, demand management shall be carried out such that the over drawl/under-injection of each control area shall not exceed 12% of scheduled value or 150 MW, whichever is lower during each 15 minute time block. ▪ In India, each inter control area transmission line is assigned a Available Transfer Capability (ATC), Total Transfer Capability (TTC) and Transmission Reliability Margin (TRM) by the Transmission Licensee (CTU). CTU gives a warning to the entities involved if the line flow exceeds ATC and then applies congestion charges over and above Unscheduled Interchange charges if it exceeds TTC.

Common guidelines for capacity allocation for long term access and short term access with mandated ATC and TTC for cross border links and between countries?

Gap Analysis of SA countries : Operation Code

Operational Liaison

Criteria	Country	Remarks
Operational Liaison	Bhutan, India, Pakistan	▪ The procedure for Operational Liaison which is provisions for quick exchange of information in relation to events which had/will have an effect on the grid/user system. ▪ Before any operation is carried out by System operator, it shall inform the grid user, whose system shall/may have experience an operational affect and also give details of the operation. The vice-versa i.e. grid user informing the system operator also is applicable.

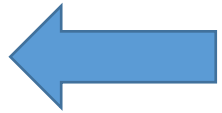


Guidelines for data communications under emergency conditions

Gap Analysis of SA countries : Operation Code

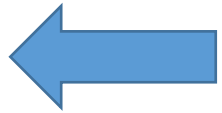
Load Shedding Schemes

Country	Automatic Load Shedding	Under frequency relays	df/dt relays	Demand Response	Grouping arrangements of Feeders/loads for Shedding
Bangladesh	Yes	Yes	-	-	Distribution Utilities shall provide estimates of discrete blocks of load that may be shed with the details of the arrangements.
Bhutan	Yes	If System operator requires	-	-	Distribution licensees shall provide details of arrangements of demand into discrete blocks to system operator.
India	Yes	Yes	Yes	Yes	Interruptible loads shall be categorised into four non-overlapping groups, scheduled, unscheduled, through under frequency/df/dt relays and through System Protection Schemes



Gap Analysis of SA countries : Operation Code

Country	Automatic Load Shedding	Under frequency relays	df/dt relays	Demand Response	Grouping arrangements of Feeders/loads for Shedding
Nepal	Yes	Yes	-	-	Distributor/HV Consumer shall split the demand into discrete MW blocks as specified by system operator.
Pakistan	Yes	Yes	-	-	System Operator shall provide automatic load shedding groups and the amount of load to be shed
Sri Lanka	Yes	Yes	-	-	Distribution details provide details Identifying feeders as essential and non-essential loads with non-essential loads further categorized in the order of priority.



Cross border Grid code would not specify load management excep in case of special protection to limit the power flow in AC interconnection

Gap Analysis of SA countries : Operation Code

Outage Planning

All grid codes specify procedures to prepare a coordinated generation and transmission outage schedule for the year ahead considering load-generation balance and operating conditions.

Country	Responsible for Final Outage Plan	Submission of Outage Plan by grid users	Release of Final Outage Plan	Review of Outage Plan
Bangladesh	Transmission Licensee	March 31	May 31	Monthly
Bhutan	System Operator	December 1	December 31	Monthly/Quarterly
India	RPC Secretariat	November 30	January 31	Monthly/Quarterly
Nepal	System Operator	Mid March	Mid May	3 year rolling plan
Pakistan	NTDC		April 30	Quarterly
Sri Lanka	Transmission Licensee	November 30	December 31	Monthly

Guide lines for outage management and information sharing between countries –Bi-lateral or SA co-ordination forum?

Annual, monthly, weekly, and daily basis

Gap Analysis of SA countries : Operation Code

Recovery Procedures & Event Information

Criteria	Country	Remarks
Recovery Procedures	All SA countries	All grid codes have laid down provisions for recovering the system from a total/partial Black Out.
	Bangladesh	Responsible by NLDC & Transmission licensee
	Bhutan, Pakistan	Responsible by System Operator
	Sri Lanka	Responsible by Transmission licensee
	India	RLDC's
Event Information	Bangladesh, Bhutan, India, Pakistan	Specify the incidents to be reported, the reporting route to be followed and information to be supplied to ensure consistent approach to the reporting of incidents/events.

Guidelines for recovery procedure under failure of cross border lines by respective system operators

All countries connected through AC and DC

Gap Analysis of SA countries : Scheduling and Dispatch Code

Schedule & Dispatch code specifies the Demarcation of Scheduling & Dispatch responsibilities among System Operator, Transmission licensees, Grid Users and other entities involved in Electricity Sector.

Task	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
Generation Dispatch	Centralized	Centralized	De-centralized	Centralized	Centralized	Centralized
Drawl/ Injection Dispatch	-	Distribution licensees & cross-border transfer to India	De-centralized. Shall be done by RLDCs	-	-	-
Nodal Agency	System Operator	System Operator	ISGS by RLDC. Intra state by SLDCs.	System Operator	System Operator	System Operator

Gap Analysis of SA countries : Scheduling and Dispatch Code

Scheduling Procedure

Task	Bangladesh	Bhutan	India	Nepal	Pakistan	Sri Lanka
Capability Declaration	Before 12 noon	0930 hrs	0800 hrs	Before 12 noon	1000 hrs	Before 12 noon
Drawl declaration	-	0930 hrs	1500 hrs	-	-	-
Dispatch Schedule Informed	1700 hrs	1800 hrs	1800 hrs	1600 hrs	1700 hrs	1500 hrs
Time blocks	1 hour	1 hour	15 minute	1 hour	Half hour	1 hour

Common Guidelines for scheduling and dispatch for cross border flows?

To adopt common time reference – Indian Standard Time

Common Settlement period – 15 minutes

Gap Analysis of SA countries : Scheduling and Dispatch Code

- Pakistan and India grid codes specify that for generators which work with different fuels, availability shall be declared with respect to each fuel type.
- Only Indian grid code has provided methodology for re-scheduling wind and solar plants on a three hourly basis.
- Indian grid code specifies that the hydro generators are expected to respond to frequency & inflow fluctuations. Hence they are free to deviate from the schedule and shall be compensated for the difference in energy on the 4th day. Other grid codes do not specify the same.
- All grid codes specify that reactive power drawl from grid is discouraged. Only Indian grid code specifies VAR drawl charges for discouraging the same.
- In India, hydro generating units of capacity 50 MW and above shall be capable of operation in synchronous condenser mode. The quantum of absorption/injection of reactive power shall be instructed by the appropriate load dispatch centre.

Gap Analysis of SA countries : Scheduling and Dispatch Code

Indian grid code has laid down regulations:

- CERC (Deviation Settlement Mechanism & related matters) regulations, 2014: Establishes a mechanism for charging the control areas for deviating from the scheduled drawl/injection.
- CERC (Power Market) Regulations 2010 and CERC (Open Access in inter- State Transmission) Regulations, 2008 establish procedures for scheduling collective transactions i.e. buyers and sellers of power to participate in power trade through Power Exchange(s).
- CERC (Sharing of Inter State Transmission Charges and Losses) Regulations, 2010 specify mechanism for sharing transmission charges and losses among designated transmission customers.

Other grid codes have not specified mechanisms for Deviation Settlement, Operating a Power Exchanges, Relieving Congestion etc.

Deviation settlement not to form part of Technical guidelines

Way Forward: Capacity Allocation & Congestion Management

The following aspects shall be considered while making guidelines for cross border Capacity Allocation & Congestion management.

- Each country shall provide ATC and TTC for specific cross border transmission paths for long term and short term trading.
- Capacity calculation methodology considering reliability margin, contingency, local system changes etc.
- Coordinated curtailments on long term allocations
- Capacity allocations for day ahead and intra day operations
- Congestion relieving mechanisms

Conclusions

Based on the comments from stakeholders in TF meeting , the draft interim report would be prepared which includes the draft guidelines and draft code for cross-border trade by considering the similar documents in the international domain.

It is requested to make a arrangement to visit/meet officials in control centres of SA nations and meeting with system planners to fine tune the framework guidelines.

Introduction : SOUTH ASIA

In South Asia, cross-border links for electricity trade have been established between India-Bhutan, India-Nepal, Bangladesh-India, Pakistan-Iran etc., and many more have been planned.

The first major interconnection between Bhutan and India was commissioned in 1984 with 220kV interconnection between Chukha (Bhutan)-Birpara (India/West Bengal). This was followed by 400kV interconnection with two 400kV, double circuit Tala (Bhutan) – Siliguri (West Bengal) lines.

The Bangladesh and India interconnection was agreed in 2009 with 500MW cross-border link and commissioned in October 2013. By 2017 end, its capacity is planned to be doubled to 1000MW.

400 kV Muzaffarpur (India)-Dhalkebar (Nepal) double circuit line is under construction and is likely to be completed by 2015 end.

Introduction : Benefits of Cross Border Electricity Trading

By interconnecting systems with different load curves and diversity, overall load factor improves and generating capacity is efficiently utilized.

The feasibility of a cross-border interconnection is a function of a large number of factors such as:

Social acceptability	Security of transmission corridor
Political decision	Economic viability
Financing of interconnection	Technical feasibility of interconnection
Long-term PPA or agreement on market coupling	Acceptability of commercial terms & conditions
Satisfactory dispute resolution mechanism	Feasibility of integrated grid operation

It can facilitate large scale integration of renewable energy which reduces dependency on fossil fuels and also diversifies energy supply.

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HARMONIZATION OF GRID CODES, OPERATING PROCEDURES AND STANDARDS TO FACILITATE/PROMOTE CROSS BORDER ELECTRICITY TRADE IN THE SOUTH ASIA REGION

- Impact Analysis

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IMPACT ANALYSIS ON PLANNING CODE

Transmission Planning Process

European Grid Code

- TSO is responsible for planning.
- Upto 30 years ahead planning term categorized as mid, long & very long term.

NERC Grid Code

- Planning coordinator performs resource adequacy analysis.
- Apart from following year, studies carried out for up to 10 years, categorized as near and long term.

SAPP Grid Code

- Utility publishes the 5 year ahead Transmission System Development Plan on an annual basis.

South Asian Countries' Grid Code

- Either a planning authority or the operator prepares the plan.
- Different time horizon followed by different countries ranging from 1 to 20 years.

- It is critical to have a coordinating agency.
- Road map with Master Plan covering the next 10 years & review annually would be best strategy.
- Understanding demand and generation profile are key affecting factors.

Planning Criteria

European Grid Code

- Contingencies listed and classified as Normal, Exceptional and Out Of Range.
- 'Network Stress Tests' performed to assess system health.

NERC Grid Code

- Contingencies are classified as Normal, events resulting in single element loss, events resulting in multiple elements loss, extreme events resulting in single element removal or cascading outage.

SAPP Grid Code

- Normal and N-1 contingency studies performed to assess reliability.
- Individual members develop criteria ensuring system security and reactive compensation.

South Asian Countries' Grid Code

- Normal and N-1 contingencies are applicable. N-1-1 also included in India.
- LFA, SCS, TRS and EMTP studies are used for planning.

- Mandate for system modelling and running studies for security assessment.
- Contingency studies for both Asynchronous and Synchronous connections.
- Necessary remedial plans must be established.
- Ensure complete evacuation, serve all loads and plan reactive compensation.

System Modeling

European Grid Code

- Demarcation of observability area to account for influence of neighbour.
- Individual Grid Models merged to form the Common Grid Model.

NERC Grid Code

- A detailed list of parameters required for accurate system modeling of each equipment is established.

SAPP Grid Code

- No Relevant Information Found

South Asian Countries' Grid Code

- System modeled down to 220 kV.
- Base case constitutes upto 5-year ahead scenarios.
- Modeling requirements established for accurate system modeling.

- Defining Observability area is critical .
- Necessary parameters of all relevant equipments must be considered for accurate modeling of the system.

Generation & Load Modeling Requirements

European Grid Code

- Large scale DGs are modeled in detailed but not accounted in transfer capacity calculations and dispatch.

NERC Grid Code

- The best model available for modeling the variable generators shall be used.
- The accuracy of the detailed dynamic model shall comply with the standards.

SAPP Grid Code

- No Relevant Information Found

South Asian Countries' Grid Code

- The Indian planning code provides elaborate list of requirements for conventional generators and loads.
- High wind/solar generation injections are studied in combination with suitable conventional dispatch scenarios

- With the increasing penetration of variable generation (wind & solar), it would be required to adequately model the impact of these generation on the system.

Permissible Normal and Emergency Limits

European Grid Code

- Aspects covered-

  Thermal limits, voltage limits, maximum loss of load / generation, short circuit limits, stability limits and voltage collapse criteria.

NERC Grid Code

- Aspects covered-

  Steady state, post contingency and transient voltage limits, power limits, secure operation in all foreseen planning events.

SAPP Grid Code

- Aspects covered-

  Voltage limits during steady state and during switching, frequency limits, loading limits, fault level and stability criteria.

South Asian Countries' Grid Code

- Aspects covered-

  Steady state voltage and loading limits, reactive power limits, fault level, transient stability for contingency criteria and planning margins.

- Steady state & stability limits and fault levels already defined can be adopted
- Apart from the above mentioned limits, the criteria for HVDC connection, Reactive compensation, substation planning must be established.

Remedial Actions

European Grid Code

- Preventive and curative remedial actions are prepared and published.
- Primarily address power flow constraints and voltage constraints.

NERC Grid Code

- Corrective action plans are prepared for planning events wherever necessary.
- System deficiencies and corresponding actions are listed.

SAPP Grid Code

- SAPP code considers corrective measures for maintaining voltage limits

South Asian Countries' Grid Code

- To ensure security of the grid, the extreme/rare but credible contingencies are identified periodically and suitable defense mechanism, are worked out.

- Contingencies shall be evaluated and remedial and corrective action shall be listed.
- If corrective action requires new elements, remedial action shall be used in interim.
- Remedial actions shall be established for normal, severe and rare contingencies.

Available Transfer Capacity Calculation

European Grid Code

- Two approaches:
  i. Net Transfer Capacity Approach
  ii. Flow Based Approach (for day-ahead and Intraday)

NERC Grid Code

- Two approaches:
  i. Area Interchange Method
  ii. Flow Gate Approach (for day-ahead and Intraday)

South Asian Countries' Grid Code

- Single Approach:
  i. Available Transfer Capability Approach

- Till development of a matured market in the South Asian region, calculations carried out by India can be adopted
- In the long term, it would be necessary to adopt a sound principle based on European / North American practice

Congestion Management

European Grid Code

- Two approaches:
  i. Net Transfer Capacity Approach
  ii. Flow Based Approach (for day-ahead and Intraday)

NERC Grid Code

- Two approaches:
  i. Area Interchange Method
  ii. Flow Gate Approach (for day-ahead and Intraday)

South Asian Countries' Grid Code

- Single Approach:
  i. Available Transfer Capability Approach

- To develop commercial principles wherein it is the responsibility of transmission agencies.
- Till the establishment of congestion reliving mechanism:
  i. Honor long term commitment by re-dispatching or counter flow.
  ii. For medium or short term transactions, curtailment as a last resort

IMPACT Analysis ON Connection Code

Applicability of Regulation

European Grid Code

- All existing and new users including:
  i. Transmission System Operator
  ii. Power Generating Modules
  iii. Demand Facility Owner
  iv. Distribution Network Operator

NERC Grid Code

- All users seeking to integrate facilities, including:
  i. Generator Owner
  ii. Transmission Owner
  iii. Distribution Provider
  iv. Load-Serving Entity

South Asian Countries' Grid Code

- All existing and new users

- Shall be applicable to the authorised transmission agencies for cross border links and the associated sub-stations.
- For other links within the country, the respective countries connection code would be applicable

Connection Agreement

European Grid Code

- The connection agreement, which includes relevant site and technical specifications, needs to be signed between the relevant network operator and the user.

NERC Grid Code

- The connection agreement needs to be signed by the applicant in accordance with the NERC Reliability Standards.

South Asian Countries' Grid Code

- The connection agreement shall be signed by the designated transmission companies of the member countries and shall be facilitated by respective country regulatory commissions.

The connection agreement shall be mandatory between the designated transmission companies of member countries for the cross-border link.

Reactive Power Requirements

European Grid Code

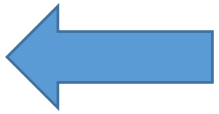
- User should maintain reactive power within limits at PCC.
- Demand facilities, pf > 0.9
- Demand facilities with onsite generation must be able to export no reactive power when active power is < 25% of Max. import capability

NERC Grid Code

- Operate close to unity power factor to minimize the reactive power burden

South Asian Countries' Grid Code

- It is recommended and even strictly followed in most countries that the interconnection is not depended on reactive support.



- Participating generators must comply with respective country's regulation.
- Reactive power flow through cross border AC links shall be limited to 0.97 lead/lag at PCC.
- As for HVDC links, voltage shall remain within limits.

Frequency Requirements

European Grid Code

- Normal operating frequency is 50 Hz.
- Permissible frequency deviation is 49 – 51 Hz
- Wider ranges can be agreed upon among the TSOs.

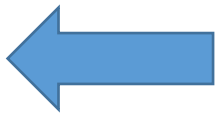
NERC Grid Code

- Operating frequency is 60 Hz.
- Permissible variation is ±0.05 Hz.

South Asian Countries' Grid Code

- Operating Frequency is 50 Hz.

	Frequency Band (Hz)
Bangladesh	49.0 – 51.0
Bhutan	49.5 – 50.5
India	49.90 – 50.05
Maldives	49.5 – 50.5
Nepal	48.75 – 51.25
Pakistan	49.5 – 50.5
Sri Lanka	49.5 – 50.5



- Recommended Frequency band of operation of synchronised interconnection shall be within 49.9 Hz to 50.05 Hz
- All the connecting equipment shall withstand the 49 to 51 Hz and for limited duration beyond the specified limits

Voltage Requirements

European Grid Code

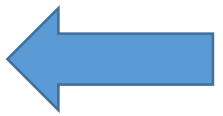
- Wide range of operating voltage is agreed between the user and system operator at the connection point
- A voltage range is defined for all equipments connected at 110 kV & above

NERC Grid Code

- The typical voltage range on the transmission system is from 90% to 105% of the nominal transmission voltages.

South Asian Countries' Grid Code

- The permissible deviations for all countries is observed to be ±5 to ±10% depending on voltage levels.



- At the point of Interconnection, acceptable range of operating voltages shall be ± 5% for 400 kV and above transmission voltage levels
- All the connected equipment shall withstand the voltage variation of ±10%

Protection & Control Schemes

European Grid Code

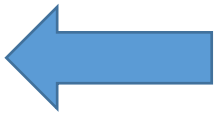
- The Relevant Network Operator shall define the schemes and settings necessary to protect the network, considering the characteristics of the Power Generating Module and Transmission connected distribution network

NERC Grid Code

- The Applicant connecting to the transmission system is responsible for proper protective equipment such that it coordinates with Transmission relays and meets all applicable standards.

South Asian Countries' Grid Code

- In India, all generators above 100 MW shall have two independent sets of main protection schemes and a backup protection scheme.
- Other nations specify one main & one back up protection scheme.



- At the connection point, respective agency shall be vested to prepare and review protection schemes according to the adopted standards in line with Article 10 of SAARC Framework Agreement for Energy Cooperation (Electricity)

Information Exchange

European Grid Code

All users shall be equipped as per the standards specified by the system operator to transfer the information within the defined time stamping.

NERC Grid Code

- Transmission system is responsible to gather real time information through Energy Management System.
- The EMS also acts as an accounting and detailed calculation platform to refine and store data.

South Asian Countries' Grid Code

- Transmission licensee is responsible for data communication through SCADA in Bhutan, Bangladesh, Pakistan and Sri Lanka.
- Grid Owner and RLDC are responsible in case of Nepal and India respectively.

- At the connection point, respective agency shall be vested to prepare and review protection schemes according to the adopted standards in line with Article 10 of SAARC Framework Agreement for Energy Cooperation (Electricity).

Connectivity Standards Applicable to Wind and other Generators using Inverters

European Grid Code

- Power quality of wind turbines and for the measurement of the related quantities shall follow IEC 61400-21 [IEC, 2008].
- The relevant parameters are active and reactive power, flicker, number of switching operations and harmonic related quantities

NERC Grid Code

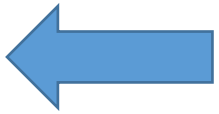
- Design considerations include IEEE Standards 142, 519, 1100, 1159, and ANSI C84.1
- Forms of power quality degradation include voltage regulation & unbalance, harmonic distortion, flicker, voltage sags & transients

South Asian Countries' Grid Code

- Except India and Sri Lanka, grid codes of other SAARC member nations do not specify the connectivity standards/requirements to be complied with by Wind and other generating stations using inverters.

The renewable energy generators (including wind and solar) shall follow the respective country code in which it is connected.

IMPACT Analysis ON Operation CODE



Operating States

European Grid Code

- For each element in its transmission system, the European grid code mandates each TSO define operational security limits.
- TSO must classify current operating condition under one of the five states in real time.

NERC Grid Code

- The NERC grid code doesn't mention any hard-set limits for the classification of the operating state of a system.

South Asian Countries' Grid Code

- Bhutan specifies the criteria for classifying an operating state as Normal/ Alert/ Emergency.
- Pakistan specifies 'N-1' contingency as emergency.
- Other nations specify different limits for Normal & Emergency conditions

- It is recommended to have the 5 classifications of the operating states, i.e. Normal, Alert, Emergency, Blackout and Restoration.
- The operating limits must be maintained at all interconnections and interconnecting substations.

Requirements of Generators

European Grid Code

- The Power Generating Modules are categorized as type A, B, C or D based on the capacity and voltage ratings.
- For each category, the requirements including frequency response, voltage stability and islanding mode are elaborated.

NERC Grid Code

For 98% of all operating hours, Generator and Transmission Operators shall have AVR in service and in automatic voltage control mode for synchronous generators or synchronous condensers and PSS in service for synchronous generators with PSS.

South Asian Countries' Grid Code

- According to the Grid codes of India, Bhutan, Bangladesh and Sri Lanka, all generating units shall have AVR in service.
- Indian Grid code also specifies that a properly tuned PSS should be in service

- The generators must follow the grid code guidelines of the respective country of their location.
- With synchronised interconnection, it may be required that all the generators be equipped with tuned PSS

Generator Reserves

European Grid Code

- The European TSOs have the possibility to access Reserve Capacity connected to another Synchronous Area, to comply with the amount of required reserves resulting from their own reserve dimensioning process of Frequency Containment Reserve, Frequency Restoration Reserve or Replacement Reserves.

NERC Grid Code

- Each Balancing Authority & Reserve Sharing Group shall maintain a minimum amount of Contingency Reserve.
- At least half of the minimum amount of Contingency Reserve shall be reserved as Operating Spinning Reserve that can respond within ten minutes.

South Asian Countries' Grid Code

- Grid codes of all SA nations except India specify that adequate operating reserves (Spinning/ Contingency/ Stand-by) shall be made available for use.
- India mentions the requirements of Instantaneous pick-up.

- The cross border links shall facilitate in the primary reserve process.
- However, it is desirable that the adequate control be established to restore the power flow to the scheduled level within a block period (15 minutes).

Short Term Demand Estimation

European Grid Code

All TSOs perform annual, summer and winter generation adequacy assessments by forecasting the weekly peak demand for each period of study for both normal and severe conditions.

NERC Grid Code

The Transmission Operator performs seasonal, next-day, and current-day Bulk Electric System studies to determine loading levels.

South Asian Countries' Grid Code

- Demand estimation for daily/ weekly/ monthly/ yearly basis is carried out.

- Short term demand forecast must be made mandatory to the extent to specify the scheduled power transfer through the cross-border links.
- This demand must be managed by respective authority without affecting grid security.

Operational Liaison

European Grid Code

An elaborate chapter is provided in one of the European Network Codes detailing of the necessary data exchange between relevant significant grid users

NERC Grid Code

Each Reliability Coordinator, Transmission Operator and Balancing Authority shall provide adequate and reliable telecommunications facilities for the exchange of Interconnection and operating information

South Asian Countries' Grid Code

- Operational liaison is briefed only in India, Pakistan and Bhutan grid codes.
- Before carrying out any operation, the system operator must notify and give details to all grid users whose system operation may get affected.

- The liaising procedure shall be adopted from the European Grid Code.
- All necessary communication and data sharing must happen over a common platform

Load Shedding Schemes

European Grid Code

- Frequency thresholds, not less than 49 Hz, are defined for load shedding by each TSO.
- Load shedding should be established in stages to minimize the further risk.

NERC Grid Code

- Each Transmission Operator shall establish plans for automatic load shedding for undervoltage conditions if the Transmission Operator, Planner(s) or Coordinator(s) determine that an under-voltage load shedding scheme is required

South Asian Countries' Grid Code

- All countries have a frequency dependent load shedding scheme in place.
- Indian Grid code of India specifies that load shedding shall be carried out to prevent over drawl when frequency is 49.5 Hz and below.

- The frequency thresholds of 49.5 Hz can be defined for automatic shedding of loads for the synchronous cross-border links.
- The loads should be classified as recommended in the Indian Grid Code and similar shedding rules may be adopted.

Outage Coordination

European Grid Code

- An outage coordination region is formed by grouping responsibility areas based on the extent of interconnection.
- A set of Power system assets are identified as relevant assets.
- Of these, few assets are listed as critical assets.
- The outage coordination planning takes all relevant assets into account

NERC Grid Code

- Each Generator Operator provides outage information to Transmission Operator daily for scheduled outages planned for next day.
- Transmission Operator establishes the outage reporting requirements and provides outage information daily to affected entities.

South Asian Countries' Grid Code

- In Sri Lanka, the transmission licensee shall establish a transmission outage program with a three year window.
- All other countries annually establish the outage plan for the following year,.

The process of selection of those important cross-border assets which have a considerable impact on the security of cross-border power flow shall be adopted from European Code.

Recovery Procedures

European Grid Code

- Each TSO prepares in advance and updates regularly a restoration plan.
- TSOs have to know the status of components of their power system after a blackout before starting the restoration process.

NERC Grid Code

Each Transmission Operator and Balancing Authority have emergency plans that enable it to mitigate operating emergencies which include communication protocols, controlling actions, coordinated tasks and the staffing levels for the emergency.

South Asian Countries' Grid Code

The relevant entities are authorized during the restoration process following a black out, to operate with reduced security standards for voltage and frequency, as necessary, in order to achieve the fastest possible recovery of the grid.

A Restoration Plan must be prepared and fixed by each region well in advance and during a black-out condition, this plan must be followed till the grid reaches a stable state

Schedule and Dispatch

European Grid Code

Scheduling agents are responsible for the transmission of their cross border schedule nominations to the responsible control area operator.

NERC Grid Code

Each Purchasing-Selling Entity that secures energy to serve Load via a Dynamic Schedule must submit a Request for Interchange as a non-time Arranged Interchange to the Balancing Authority.

South Asian Countries' Grid Code

- Generators are responsible to provide their capability for the day-ahead schedules.
- In India, Pakistan and Sri Lanka, current day revisions are also allowed.

- Day ahead scheduling procedure is recommended for the cross border links.
- A common time of Indian Standard Time (IST) can be adopted for uniformity.
- Till the development of secure cross border scheduling mechanism, the Indian scheduling and Dispatch procedure may be followed.
- The scheduling duration prevalent in India including the time block for the cross border transaction can be adopted as agreed in the TF 2 meetings

Charges for Losses

European Grid Code

- The Regulation established an ITC fund to compensate TSOs for the costs incurred in hosting cross-border flows.
- The fund aims to cover the cost of transmission losses and making infrastructure available, for cross-border flows.

NERC Grid Code

Settlement of losses shall be either handled as financial or as payment in-kind in accordance with the Transmission Service Provider tariff.

South Asian Countries' Grid Code

- The energy losses in the transmission system shall be compensated by the customers with additional injection at the injection point(s).

- In order to encourage the cross border energy exchange, it may be necessary to follow the mechanism similar to European practice wherein a scheduled fund can be created and the losses be compensated through this fund.
- The transmission agencies need to procure additional energy to compensate for the losses.

IMPACT ANALYSIS ON Metering CODE

Applicability

NERC Grid Code

- The code is applicable to Generator owners, Balancing Authority and Transmission Operator in accordance with reliability standards

South Asian Countries' Grid Code

- In India and Nepal, metering code applies to all the generating companies and licensees.
- In Sri Lanka, it is applicable to all licensees who are authorized to carry out distribution / transmission activities.
- For other countries, the same is not explicitly mentioned in their grid codes.

Metering code shall be applicable for Generators specified for cross-country transaction, Transmission system operators and distribution system/ Balancing Authority.

Standards Followed

NERC Grid Code

- The Metering equipment shall act in accordance with American National Standards Institute (ANSI) standards.

South Asian Countries' Grid Code

- The meters in India shall comply with BIS.
- Pakistan, Sri Lanka, Nepal and Bangladesh follow IEC standards.
- Bhutan and Bangladesh follows their own country specific meter standards.

IEC Standards shall be followed for the Metering.

Ownership

NERC Grid Code

- Transmission operator is responsible for properly maintaining its metering equipment.
- . Meter information is automatically and electronically communicated to Transmission operator

South Asian Countries' Grid Code

- In all the countries the meters placed in transmission system are owned and maintained by Transmission licensees.
- In all countries, billing is processed by system operators.

- All meters for interconnection shall be owned by Government designated Transmission Licensee.
- Energy Accounting and Audit functions shall be carried out by coordinating forum or the planning committee or separate agency.

Meter Location

NERC Grid Code

- For all Transformers connected through transmission, metering points are provided at the secondary side of all through-transmission transformers.
- Generators and transformers that are not through transmission but are tapped directly on the EHV system are provided with interchange metering on the primary side of the step-up, station service or radial transformer

South Asian Countries' Grid Code

In all countries the meters shall be located at outgoing feeders of generation substation

It is recommended that energy meters shall be provided at both sides of the connection point.

Operation and Maintenance

NERC Grid Code

- The owner for that meter shall take responsibility for operation and maintenance. The relevant Transmission operator maintains a metering database for auditing purposes.

South Asian Countries' Grid Code

- In Bangladesh, India and Pakistan, maintenance works of meters is carried out by the generating company or the licensee or distribution licensee.
- In Sri Lanka, Nepal and Bhutan, meter maintenance is by Transmission Licensee.

The designated transmission agency of the country shall be responsible to carry out the operation and maintenance activities.

Meter Reading & Recording

NERC Grid Code

- Meter readings shall be transmitted to the System Operator for Billing.
- Any generation unit participating in the Energy Market is required to have independent metering devices.
- Backup meters of sufficient accuracy to serve as a replacement for the primary metering system.

South Asian Countries' Grid Code

- All countries have the provision to transfer the meter readings which are connected at transmission connection point to remote location through data communication channels.
- In India, Nepal, Sri Lanka, Bhutan and Bangladesh, in case of meter failure, the data is taken from backup meters.

Meter reading and recording functions shall be carried out by coordinating forum or the planning committee or a separate agency

Access to Meters

NERC Grid Code

The Equipment owner of the premises where the meter is installed shall provide access to the transmission system operators for installation, testing, commissioning, reading and recording and maintenance of meters.

South Asian Countries' Grid Code

The owner of the premises where the meter is installed shall provide access to the authorized representative(s) of the licensee for installation, testing, commissioning, reading and recording and maintenance of meters.

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

THANK YOU