

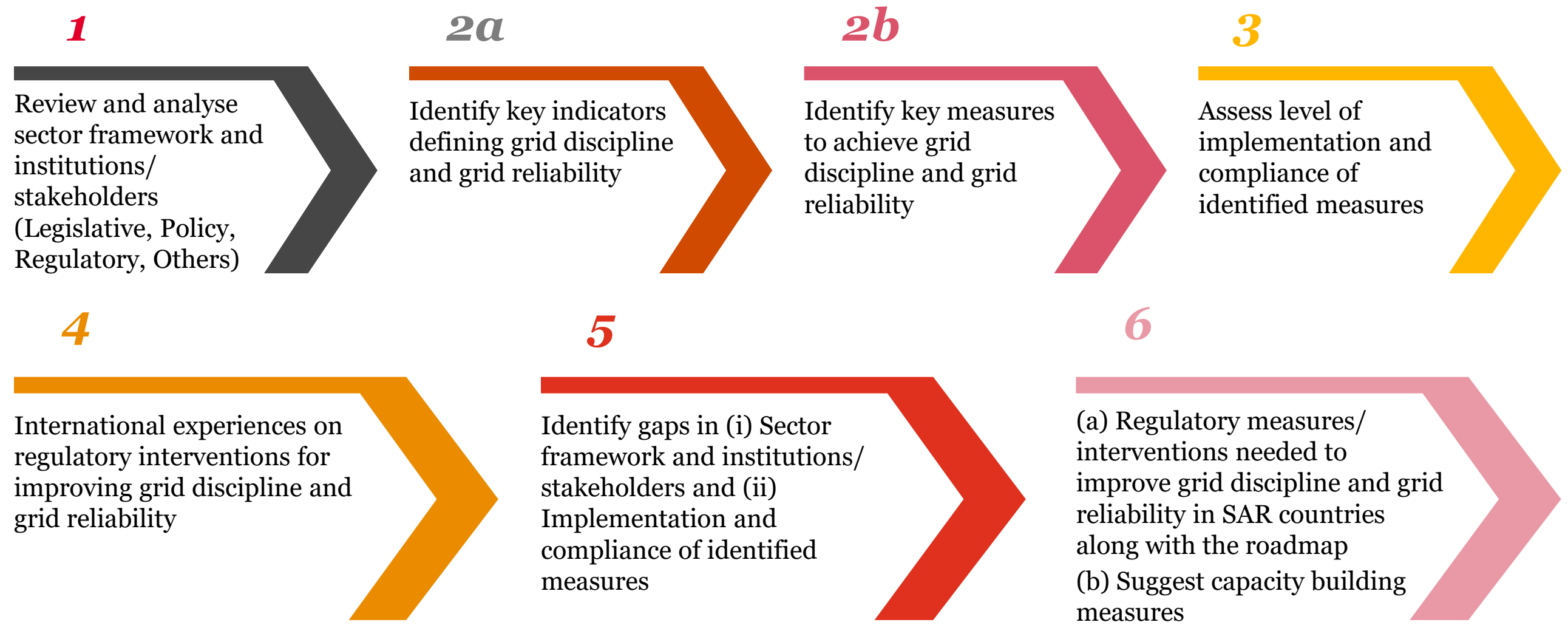
03 Key Findings of the SWG Draft Research Study Report on “Regulatory Interventions for Grid Discipline and Grid Reliability (GDR) in the South Asian Region

Presented by

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03.1 Approach and Methodology



03.2 Key indicators defining GDR

Frequency Variation

- Most important parameters for assessment of security and quality of power supply in any grid
- Has impact on generator voltage & passive transmission network elements
- Measured by % of times frequency breaches given limits

Voltage Variation

- Can occur in power system due to multiple reasons (inadequate supply of reactive power, overloaded/underloaded circuits, etc.)
- May lead to malfunctioning of equipment
- Measured by % of times voltage breaches normal operating limits and contingency limits

Planning Reserve Margin

- Designed to measure amount of generation capacity available to meet expected demand in planning horizon
- Provides indication of the additional capacity available to meet unforeseen - increases in demand, outages and trends
- Reserve Margin (%) = $(\text{Capacity} - \text{Load}) / \text{Load} \times 100$

Frequency Response

- Measure of interconnection's ability to stabilize frequency immediately following sudden loss of generation or load
- Frequency response = $(\Delta \text{Demand} + \Delta \text{Generation}) / \Delta \text{Frequency}$, in MW/Hz

Partial or Complete Grid Disturbance

Measured in number of outages and duration of outages

Tripping per line and Tripping duration per line

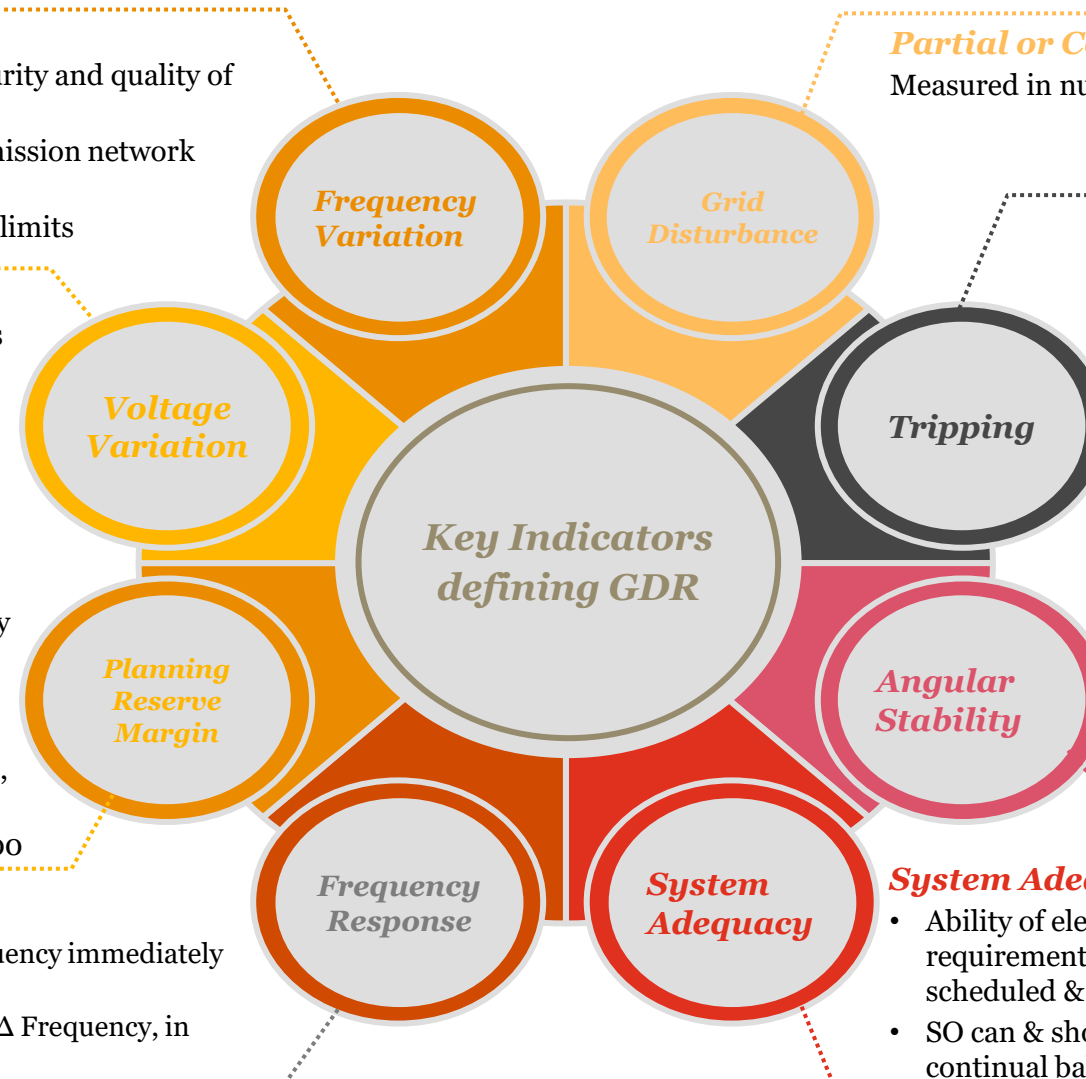
- Count of interruptions over period of time (daily / weekly/ monthly/ yearly)
- Tripping duration - interval of time electric line is tripped
- Frequency and duration of tripping - indication of performance measured at a balancing area level or interconnection level

Angular Stability

- Measured using phase angle difference
- Real-time angle difference between nodes, sampled from widely dispersed locations in the power system network and synchronized from common time source of a GPS radio clock, provides SO with an immediate awareness of system strength and stress

System Adequacy

- Ability of electricity system to supply aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled & reasonably expected unscheduled outages of system elements
- SO can & should take controlled actions or procedures to maintain a continual balance between supply & demand within its control area by public appeals & interruptible demand



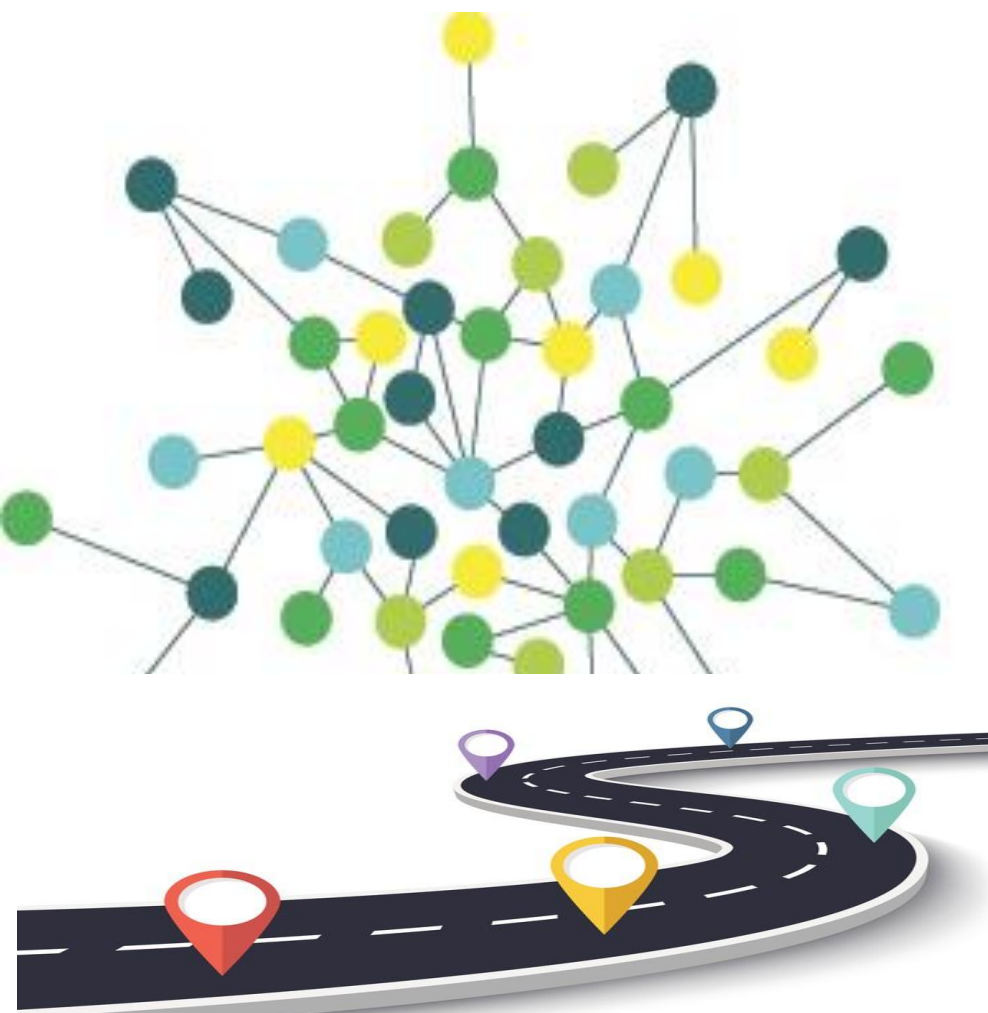


03.3

Draft Suggested Regulatory Measures/Interventions &

03.4

Suggested Specific Technical Capacity Building Measures



03.3.1 Key recommendations – South Asia Region

Regional regulatory recommendations in the South Asia Region for improving grid discipline & reliability



Recommendation

Area of Intervention	Suggested regulatory intervention
System planning	Specify a detailed transmission planning criteria to be followed by Transmission Licensee to achieve economies of scale, reduction in network congestion, strategy for generation & load alternatives and renewable energy integration.
System construction and safety	Grid code to have provisions related to system construction and safety like standards for general safety requirements and Designate the responsibility to monitor compliance to promote grid discipline and grid reliability
Grid connection	Lay down detailed procedure for grid connections for users including renewable energy generators. Standardize process for grid connectivity by defining test requirements for power system elements for synchronous & non-synchronous generator and HVDC & FACTS devices for ensuring power system safety.
System operation	Publish procedure for operational planning, system security, demand management, outage management and partial or complete grid disturbance, define key system performance indicators, define grid incidence and grid disturbance events.
	Develop ancillary service market for primary, secondary and tertiary responses in the country.
	Introduce incentive / penalty-based imbalance settlement mechanism and the rules and procedure for implementation of the same.
Scheduling and despatch	Specify penalty for mis-declaration by the generating companies and inaccurate demand forecasting by distribution companies.
	Specify framework for co-ordination of CBET with details of identified roles and responsibilities of various stakeholders, standard contracts for export and import of power, grid safety related provisions for CBET.
Information and comm. technology	Push for adoption of advanced technology including Information and Communication Technology (ICT). specify cyber security related aspects to identify critical information infrastructure.
Monitoring and compliance	Lay down provision for periodic publishing of monitoring and compliance reports, system performance reports, third-party audit reports and other such important documents in the public domain.
	Define and mandate capturing information on grid performance indicators for effective reporting of status of grid reliability.

Institutional Interventions – Proposed regional regulatory agency, i.e., South Asia Forum of Electricity / Energy Regulators (SAFER)/ to act as neutral, apolitical forum/ platform for regulators and experts to assemble, brainstorm, strategize and recommend specific steps to address the multiple barriers to CBET is proposed. Existing Institution/Institutional mechanism such as SAFIR, SAARC council of experts of Energy(Electricity) may also take up such role.



Bangladesh: Identified regulatory gaps, interventions and proposed roadmap

Proposed roadmap



Identified regulatory gaps and corresponding intervention

G1	<i>Absence of transmission planning manual</i>	BERC to develop transmission planning manual
G2	<i>Inadequate measures in system construction and safety.</i>	BERC to define the rules and procedure for monitoring compliance to system construction and safety regulations
G3	<i>Absence of System Protection Philosophy and third-party protection audits</i>	BERC to define mechanism for strengthening of power system protection through white paper or consultation paper
G4	<i>Absence of ancillary services market in Bangladesh</i>	Develop ancillary service market in Bangladesh
G5	<i>Absence of detailed framework for CBET</i>	BERC to specify framework for co-ordination of CBET
G6	<i>Inadequate regulatory push to regularly assess adequacy of current technology & recommend more effective technology solutions</i>	BERC to define and mandate capturing information on grid performance indicators

Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
Working paper to be floated on transmission planning criterion	Draft amendments to the Grid code for deliberations and finalisation	Appropriate amendments to Grid code to operationalize transmission planning criteria.
Grid code to mandate conducting independent third-party safety audits biennially	<ol style="list-style-type: none"> 1. Regulator to mandate conducting independent third-party safety audits once a year and internal audits once every quarter. 2. Monitor compliance to the same. 	
BERC to mandate TSO to define protection system philosophy.	<ol style="list-style-type: none"> 1. The System Protection Working group/ committee at NLDC to frame appropriate standard specifications for Protection Systems 2. Grid code to mandate independent third-party audit 	
Publish consultation paper/ white paper	<ol style="list-style-type: none"> 1. Develop Regulations to enable ancillary services market. 2. Regulations to introduce secondary response through AGC and market-based price discovery. 	
Comprehensive study to understand role played by various stakeholders for CBET in Bangladesh	BERC to draft specific Regulations defining framework for coordination of CBET.	Form separate specialized department within PGCB to coordinate CBET effectively.
Publish consultation paper/ white paper on regulatory intervention for cyber security code	BERC to publish cyber security standards covering standards for ICT, identification of data transfer protocols, measures for information protection, provision for cyber audits & capacity building	

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03.3.3



Bhutan: Identified regulatory gaps, interventions and proposed roadmap



Identified regulatory gaps and corresponding intervention

G1	<i>Absence of transmission planning manual</i>	BEA to develop transmission planning criterion
G2	<i>Inadequate measures in system construction and safety.</i>	BEA to define mechanism for strengthening of power system safety
G3	<i>Absence of System Protection Philosophy and third-party protection audits</i>	BEA to specify system protection philosophy, protection schemes and guidelines for testing & commissioning.
G4	<i>Bhutan has not capitalised its hydro power resources by offering ancillary services</i>	Develop ancillary service market in Bhutan
G5	<i>Absence of detailed framework for CBET</i>	BEA shall specify framework for co-ordination of CBET
G6	<i>Absence of Cyber security standards for critical information infrastructure</i>	Regulations/ codes/ rules for implementation of ICT infrastructure like communication facilities, operational technology systems and Cyber Security

Proposed roadmap

Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
Working paper to be floated on transmission planning criterion	Draft amendments to the Grid code to be prepared for deliberations and finalisation	Appropriate amendments to Grid code to operationalize transmission planning criteria.
Conduct study on international best practices and propose approach for their adoption	1. Define safety standards and make necessary provisions for their compliance. 2. Make provisions to conduct independent third-party safety audits annually	
BEA to mandate TSO to define the protection system philosophy.	1. System Protection Working group/ committee at NLDC to frame appropriate standard specifications for Protection Systems 2. Grid code to mandate independent third-party audit	
Publish consultation paper/ white paper	Develop Regulations to enable ancillary services market.	Regulations to introduce secondary response through AGC and market-based price discovery.
Conduct study to understand role played by various stakeholders for CBET in Bhutan	BEA to draft specific Regulations defining framework for coordination of CBET.	Form separate department within BPSO to coordinate CBET effectively
BEA to publish consultation paper/ white paper on regulatory intervention for cyber security code	BEA to publish cyber security standards which encompass standards for ICT, identification of data transfer protocols, measures for information protection, provision for cyber audits & capacity building	

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03.3.4



India: Identified regulatory gaps, interventions and proposed roadmap (1/2)



Proposed roadmap

Identified regulatory gaps and corresponding intervention

G1 *Update Transmission system planning manual with present day system planning techniques*

Initiate revision of transmission system planning manual and introduce international best practices for planning

G2 *Resilience of present Regulation for ancillary services is inadequate. Efforts to introduce de-linking of payment from pool account and improving response time for secondary and tertiary services to be made*

Take necessary steps to make ancillary service market framework more resilient

G3 *Currently no post-despatch analysis is conducted and there is no/ inadequate compensation to generators forced to run below normative parameters*

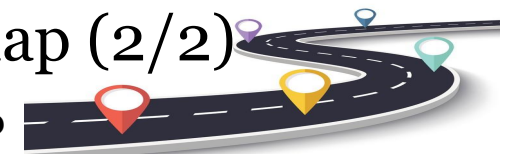
Introduce provisions related to post despatch analysis and compensating generators that are compelled to run below normative parameters as per grid code

Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
<ol style="list-style-type: none"> 1. Mandate SLDCs to prepare scenario based probabilistic demand 2. CEA to assess storage systems for demand response measures 	<ol style="list-style-type: none"> 1. Introduce framework to ensure better utilisation of existing infrastructure 2. Promote transmission system operators to conduct contingency analysis based on contingency list 	<p>Impose penalty/ claw back on transmission operator(s) for non-compliance to contingency analysis and contingency listing</p>
<ol style="list-style-type: none"> 1. Consultation paper/ white paper outlining methodology for accurately assessing primary, the response time of secondary and tertiary reserves 2. Introduce secondary response through AGC and market-based price discovery of ancillary services 	<p>Devise a framework to modify payments provisions of Ancillary Services</p>	<p>Introduce energy storage systems and fast transient frequency support using controlled inertial response from wind turbines</p>
<p>Regulatory intervention to compensate generating stations that are compelled to operate below normative plant availability factor.</p>	<p>Introduce provisions related to post-despatch analysis in the grid code.</p>	

03.3.4



India: Identified regulatory gaps, interventions and proposed roadmap (2/2)



Identified regulatory gaps and corresponding intervention

Proposed roadmap

Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
<p>G4 <i>Grid code lacks adequate provisions to ensure robust cyber security</i></p> <p>Make interventions for building cyber security code for power systems, ensuring capacity building of concerned stakeholder</p>	<ol style="list-style-type: none"> Develop consultation paper/ white paper on cyber security, Develop cyber security code, 	<p>Publish cyber security code for various communication technologies, identification of data transfer protocols, measures for information protection, provision for cyber audits and capacity building.</p>
<p>G5 <i>RPCs conduct system protection studies and lay down regional system protection standards that are not necessarily standardized.</i></p> <p>Regulatory intervention to standardise protection plans to introduce best practices like creation of system defence plan as a proactive step for system protection</p>	<ol style="list-style-type: none"> Regulator shall recommend having a common protection philosophy for grid users at national level. Grid Code shall mandate regular protection audit plans for internal and third-party audits. 	<p>Push for mandating the compliance to international standards by the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) for ICT infrastructure.</p> <p>Regulator shall specify penalty/ claw back for non-compliance to system defence planning on NPC/ RPCs.</p>

03.3.5

Contents | [Suggested Regulatory Measures/ Interventions](#) | Sector framework and institutions/ stakeholders | Key Measures to achieve GD&R
 Assess level of implementation and compliance of identified measures | International experiences and best practices on Regulatory Interventions on GDR
 International experiences and best practices on Regulatory Interventions on GDR | Suggested specific technical capacity building measures



Nepal: Identified regulatory gaps, interventions and proposed roadmap



Proposed roadmap

Identified regulatory gaps and corresponding intervention

		Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
G1	<i>Absence of transmission planning criterion</i> ERC of Nepal to develop transmission planning criterion	Working paper to be floated on transmission planning criterion	Draft and notify transmission planning criterion	
G2	<i>Inadequate measures in system construction and safety.</i> ERC of Nepal to define mechanism for strengthening of power system safety	Conduct a study on international best practices and propose approach for their adoption	<ol style="list-style-type: none"> 1. Define safety standards and make necessary provisions for their compliance. 2. Make provisions to conduct independent third-party safety audits annually 	
G3	<i>Absence of System Protection Philosophy and third-party protection audits</i> ERC of Nepal to specify system protection philosophy, protection schemes and guidelines for testing & commissioning.	Publish consultation paper/ white paper	<ol style="list-style-type: none"> 1. Finalise and notify Regulations for Imbalance Settlement Mechanism 2. Issue rules and procedure to operationalize 	
G4	<i>Absence of ancillary services mechanism in Nepal</i> Develop ancillary service market in Nepal	Develop Regulations to enable ancillary services market.	<ol style="list-style-type: none"> 1. Market-based operation to be established for providing ancillary services in Nepal 2. Explore scope for participation in SAR ancillary services market 	
G5	<i>Absence of detailed penalty mechanism in Grid Code/ Regulations</i> Introduce incentive / penalty-based imbalance settlement mechanism	Develop system protection philosophy, schemes and guidelines	<ol style="list-style-type: none"> 1. Provisions to conduct independent third-party safety audits annually. 2. Penalty provisions for non-compliance to the system protection, testing and commissioning standards 	
G6	<i>No clear mandate to publish information related to power system in public domain</i> Lay down provision for periodic publishing of monitoring and compliance reports in the public domain.	<ol style="list-style-type: none"> 1. ERC of Nepal to mandate periodic publishing of various monitoring and compliance reports. 2. Explore imposing penalties for non-compliance 		-

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03.3.6



Pakistan: Identified regulatory gaps, interventions and proposed roadmap



Proposed roadmap

Identified regulatory gaps and corresponding intervention

G1	<i>No mechanism to ensure compliance to system planning standards</i>
	NEPRA to introduce penalty provisions for non-compliance of system planning standards
G2	<i>Absence of imbalance settlement mechanism</i>
	NEPRA to introduce incentive / penalty-based imbalance settlement mechanism
G3	<i>Absence of a commercial mechanism/ market for providing ancillary services</i>
	NEPRA to introduce a commercial mechanism for ancillary services (primary, secondary and tertiary responses)
G4	<i>Absence of detailed framework for CBET</i>
	NEPRA to specify framework for co-ordination of CBET
G5	<i>Inadequate regulatory push to regularly assess adequacy of current technology to manage grid operations and recommend more effective technology solutions</i>
	NEPRA to encourage adoption of technology solutions for improving system operations, market operations, grid reliability and cyber security
G6	<i>Absence of mechanisms to monitor performance standards of transmission licensee</i>
	Introduction of incentive/ penalty mechanism for improving transmission system availability

Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
Introduce penalty provisions for non-compliance	-	
Publish consultation paper/ white paper	Rules and procedure for implementation of the incentive/ penalty-based mechanism to be issued after comprehensive stakeholder consultations	
Publish consultation paper/ white paper	Issue Regulations on ancillary services (covering primary and tertiary)	Issue Regulations on secondary response through AGC and market-based price discovery of ancillary services
Conduct study - Role played by various stakeholders for CBET	Issue Regulations defining framework for coordination of CBET	Form separate department within the System Operator for CBET coordination
Publish consultation paper/ white paper	Mandate phased adoption of technology solutions for improving system operations, market operations, grid reliability and cyber security	
Develop Regulations for claw back mechanism or penalty provisions for the transmission licensee(s)		-

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03.3.7



Sri Lanka: Identified regulatory gaps, interventions and proposed roadmap



Proposed roadmap

Identified regulatory gaps and corresponding intervention		Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
G1	<i>No mechanism to ensure compliance to system planning standards</i> PUSCL to introduce penalty provisions for non-compliance of system planning standards	Introduce penalty provisions for non-compliance		-
G2	<i>Absence of imbalance settlement mechanism</i> PUSCL to introduce incentive / penalty-based imbalance settlement mechanism	Publish consultation paper/ white paper	Rules and procedure for implementation of the incentive/ penalty-based mechanism to be issued after comprehensive stakeholder consultations	
G3	<i>Absence of a commercial mechanism/ market for providing ancillary services</i> PUSCL to introduce a commercial mechanism for ancillary services (primary, secondary and tertiary responses)	Publish consultation paper/ white paper	Issue Regulations on ancillary services (covering primary and tertiary)	Issue Regulations on secondary response through AGC and market-based price discovery of ancillary services
G4	<i>Absence of detailed framework for CBET</i> PUSCL to specify framework for co-ordination of CBET	Conduct study to understand - role played by various stakeholders for CBET	Issue Regulations defining framework for coordination of CBET	Form separate department within the System Operator for CBET coordination
G5	<i>Inadequate regulatory push to regularly assess adequacy of current technology to manage grid operations and recommend more effective technology solutions</i> PUSCL to encourage adoption of technology solutions for improving system operations, market operations, grid reliability and cyber security	Publish consultation paper/ white paper	Mandate phased adoption of Technology solutions for improving system operations, market operations, grid reliability and cyber security	
G6	<i>Inadequate performance monitoring indicators</i> PUSCL to define and mandate capturing information on grid performance indicators for effective reporting of status of grid reliability	PUSCL to define performance indicators of grid reliability (Dependability Index, Security Index, Reliability Index, Available Transfer Capability, Contingency Violation etc.)		-

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03.4

Suggested Specific Technical Capacity Building Measures



03.4

Suggested capacity building measures

(1/2)

#	Training Name	Relevant Audience	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
1	Introduction to Grid Discipline and Reliability	Regulators	Y	Y	Y	Y	Y	Y	Y	Y
2	Capacity Building on Development of Grid Code	Regulators	Y	N	N	N	Y	Y	N	N
3	Capacity Building on Development of System planning Manual and Long term Transmission Plan	Regulators/ Technical Authority for electricity standards/ Transmission operator	Y	Y	Y	N	Y	Y	N	N
4	Formulation of Penalty/Incentive provisions for promoting Grid Discipline	Regulators	Y	Y	Y	N	N*	Y	Y	Y
5	Training Programme on International Best Practices in Transmission System planning	Technical Authority for electricity standards/ Transmission operator	N#	Y	Y	Y	N*	Y	Y	Y
6	Strengthening standards for system safety and grid connection.	Regulators/ Technical Authority for electricity standards/ Transmission operator	Y	N	Y	Y	N*	Y	Y	Y
7	System Protection- Best Practices and Enforcement Regulations	Regulators	Y	Y	Y	Y	N	Y	Y	Y

*Can be allotted when basic transmission system is developed

#After Afghanistan develops its Transmission system manual

* after creation of transmission system

only after system planning manual

03.4

Suggested capacity building measures

(2/2)

#	Training Name	Relevant Audience	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
8	Balancing the Grid- Ancillary services	Regulators	Y	Y	Y	Y	N*	Y	Y	Y
9	Strengthening of Outage Management	Regulators/ Technical Authority for electricity standards/ Transmission operator	Y	Y	Y	N	N*	Y	Y	Y
10	Information and Communications Technology - Best Practices and Implementation	Regulators	Y	Y	Y	Y	Y	Y	Y	Y
11	Capacity Building on Regulatory framework for Cyber Security	Regulators	Y	Y	Y	Y	Y	Y	Y	Y
12	Capacity Building on Assessment of Investments in GDR	Regulators/ Transmission operator	Y	Y	Y	N	Y	Y	Y	Y
13	Capacity Building for Disclosure of GDR related Information to General Public	Regulators/ Transmission operator	Y	Y	Y	Y	Y	Y	Y	Y
14	Power system simulation exercise	Transmission operator/ System operator	Y	Y	Y	Y	N*	Y	Y	Y

*Can be allotted when basic transmission system is developed

* after creation of transmission system

Thank You

03.3.8

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International experiences and best practices on Regulatory Interventions on GDR | Suggested specific technical capacity building measures



Afghanistan: Identified regulatory gaps, interventions and proposed roadmap

Identified regulatory gaps and corresponding intervention

G1	<i>Absence of independent electricity regulator and codes</i>
	Independent electricity regulator to regulate sector participants, to specify sector code and their enforcement to be created under the empowering act.
G2	<i>Absence of planning manual, codes for construction & safety and grid connection</i>
	Regulator to develop transmission planning criteria, define mechanism for strengthening of power system safety and laydown detailed procedure for grid connectivity
G3	<i>Absence of ancillary market, imbalance settlement method and CBET framework</i>
	Development of ancillary service market for relieving congestion and minimising frequency fluctuations. Introduce incentive / penalty-based imbalance settlement mechanism and laydown detailed procedure for CBET
G4	<i>Improvement in ICT and measures for robust monitoring and compliances</i>
	Implementation of ICT (e.g., SCADA/EMS, WAMS/PMU) and guidelines for ensuring cyber security. Lay down provision for periodic publishing of relevant reports highlighting grid performance

Proposed roadmap



Short Term (≤ 3 years)	Medium Term (3-6 years)	Long Term (> 6 years)
<ol style="list-style-type: none"> 1. Creation of independent electricity regulator 2. Regulator notify grid code after consultation 	-	-
Grid code have provision for system planning, const. & safety and grid connection	<ol style="list-style-type: none"> 1. Working paper on planning criteria 2. Conduct a study for strengthening safety 3. Publish white paper on grid connectivity 	<ol style="list-style-type: none"> 1. Notification of planning criteria 2. Define safety standards & compliance 3. Provisions to conduct 3rd party safety audits
Grid code have provision for management of frequency response by providing ancillary services, imbalance settlement mechanism and coordination of CBET	<ol style="list-style-type: none"> 1. Conduct study on intro. ancillary services 2. A white paper on progressive narrowing of frequency band 3. Study on for building CBET framework. 	<ol style="list-style-type: none"> 1. Regulator to explore establishing market-based ancillary services. 2. Rules for incentive/penalty-based framework 3. Draft regulation on CBET framework
<ol style="list-style-type: none"> 1. Grid code has provision for implementation of advance ICT infra & cyber security measures 2. Grid code should mandate - publishing of monitoring & compliance reports 	<ol style="list-style-type: none"> 1. Conduct study to prepare roadmap for adoption of advanced ICT infra 2. Consultation paper on cyber security 3. Regulator to publish monitoring & compliance reports 	<ol style="list-style-type: none"> 1. Regulator to mandate use of advanced ICT technologies 2. Regulator to publish cyber security standards 3. Regulator to explore imposing penalties for non-compliance of reporting

Study on Regulatory Interventions for Grid Discipline and Grid reliability in the South Asian Region



Maldives: Identified regulatory gaps, interventions and proposed roadmap

1

Currently, Maldives has no transmission grid. Physical dispersion of the islands makes it virtually impossible to connect the entire country on a single grid. Due to its geographic location, surrounded by ocean, with nearly 1000 kms to the nearest mainland, even cross border electricity trade has not been considered as a viable option for Maldives.

2

The Ministry of Environment and Energy report 'Greater Malé Region Renewable Energy Integration Plan' and the USAID report 'Maldives Submarine Cable Interconnection Pre-feasibility Study' give a detailed analysis of options for undersea electrical interconnections in Greater Malé. Both studies clearly show that interconnections would support significant increases in renewable energy deployment.

3

Large-scale renewable energy deployment in Greater Malé will require the islands of Malé, Villingili, Thilafushi, Gulhifalhu and Hulhumalé/ Hulhulé to be interconnected using undersea electrical cables.

4

Considering the possible future inter connections in Maldives, we suggest that capacity building for drafting regulations covering the following shall be initiated to ensure grid discipline and reliability:

- System Planning
- System Construction and Safety
- Grid Connection
- System operation
- System protection, testing and commissioning
- Scheduling and Despatch
- Information and Communication technology
- Monitoring and Compliance

