North Eastern Regional Load Despatch Centre (NERLDC)
Shillong

RELIABILITY & TRANSFER CAPABILITY CONCEPTS

Outline

- Basics of Reliability
  - Calculation of TTC/ATC
  - Congestion Management
- Transmission Capacity vs Transfer Capability
- Transmission Planning Criteria
- National Reliability Council for Electricity

Reliability-definitions

- A measure of the ability of a system, generally given as numerical indices, to deliver power to all points of utilization within acceptable standards and in amounts desired. (The International Council on Large Electric Systems (CIGRE) definition)

- Reliability is the probability of a device or a system performing its function adequately, for the period of time intended, under the operating conditions intended. (IEEE Power & Energy Society (PES) definition)

Reliability

- **Reliability**
  - Adequacy
  - Security

    - **Adequacy relates to the existence of sufficient facilities within the system to satisfy the consumer load demand at all times.**
    - **Security relates to the ability to withstand sudden disturbances**

Reasons for Congestion

- Open Access (Electricity Act 2003)
- Lack of co-ordination

Relieving Congestion

- Standing Committee on Power System Planning
- Operational Feedback

Congestion Regulation

- Congestion Regulations of CERC notified on 22.12.09 (Gazette : 24.12.09)
- Order on Congestion Charges issued by CERC on 17.03.10
- Congestion Procedures of CERC issued on 11.06.10 & revised on 22.04.13

Procedure for Relieving Congestion in Real Time Operation

Terminologies

- **Total Transfer Capability (TTC) means** the amount of electric power that can be transferred reliably over the inter-control area transmission system under a given set of operating conditions considering the effect of occurrence of the *worst* credible contingency

- **"Credible contingency"** means the likely-to-happen contingency, which would affect the Total Transfer Capability of the inter-control area transmission system
  - Outage of single transmission element (N-1) in the transmission corridor or connected system whose TTC is being determined
  - Outage of the largest unit in the importing control area station.

- **Available Transfer Capability (ATC)"** means the transfer capability of the inter-control area transmission system available for scheduling commercial transactions (through long term access, medium term open access and short term open access) in a specific direction, taking into account the network security.
- Mathematically ATC is the Total Transfer Capability less Transmission Reliability Margin.
- **"Transmission Reliability Margin (TRM)"** means the amount of margin kept in the total transfer capability necessary to ensure that the interconnected transmission network is secure under a reasonable range of uncertainties in system conditions;

Assessment of Transfer Capability

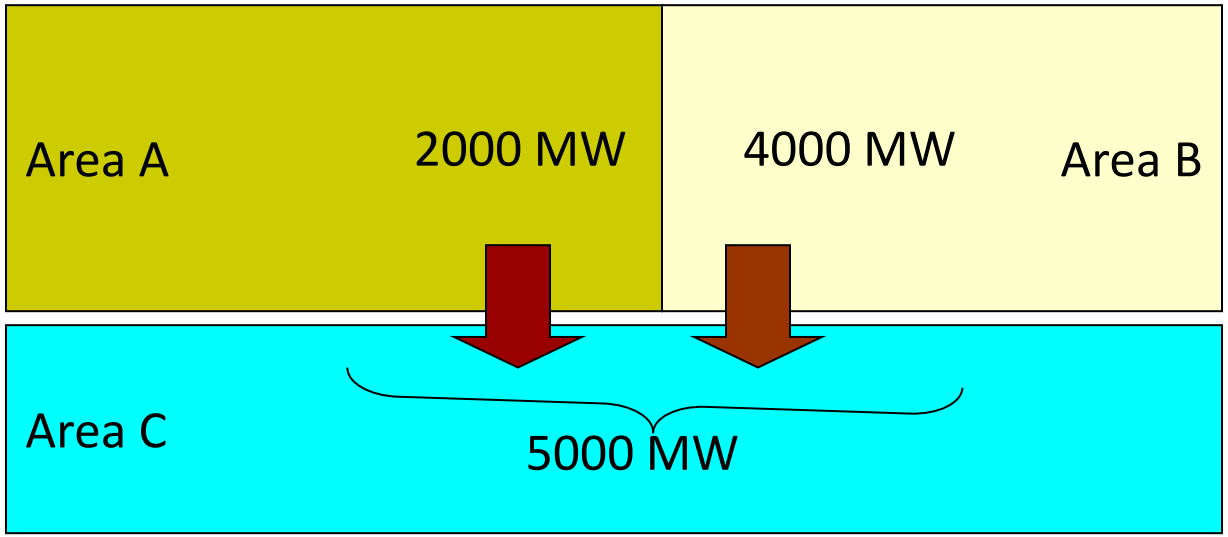
- **Computation of TRM :**

  - **2% of anticipated peak demand in MW**
  - **size of the largest generating unit**
  - ~~**size of largest anticipated infeed**~~

- **ATC = TTC – TRM**

- **ATC is the transfer capability commercially available for scheduling**

Simultaneous TTC



Relevance of Transfer Capability in Indian Electricity Market

- 3(2) The short-term open access allowed after long / medium term by virtue of-
  a) Inherent design margins;
  b) Margins available due to variation in power flows; and
  c) Margins available due to in-built spare transmission capacity created to cater to future load growth or generation addition.

Reliability Margins- Inference

- **Grid Operators' perspective**
  - Reliability of the integrated system
  - Cushion for dynamic changes in real time
  - Operational flexibility
- **Consumers' perspective**
  - Continuity of supply
  - Common transmission reserve to take care of contingencies
  - Available for use by all the transmission users in real time

Open Access Theory & Practice Forum of Regulators Report, Nov-08

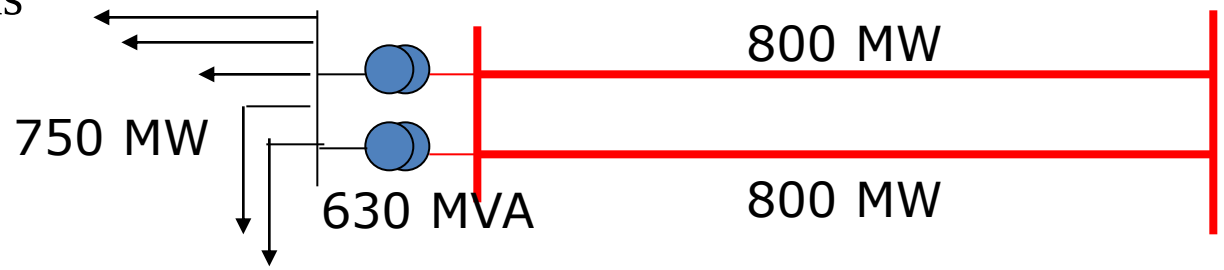
- "For successful implementation of Open Access, the assessment of available transfer capability (ATC) is very important.
- A pessimistic approach in assessing the ATC will lead to under utilisation of the transmission system.
- Similarly, over assessment of ATC will place the grid security in danger."

Transmission Capacity Vs Transfer Capability

	Transmission Capacity	Transfer Capability
1	Declared by designer/ manufacturer	Declared by the Grid Operator
2	Is a physical property in isolation	Is a collective behaviour of a system
3	Depends on design only	Depends on design, topology, system conditions, accuracy of assumptions
4	Deterministic	Probabilistic
5	Constant under a set of conditions	Always varying
6	Time independent	Time dependent
7	Non-directional (Scalar)	Directional (Vector)
8	Determined directly by design	Estimated indirectly using simulation models
9	Independent of Parallel flow	Dependent on flow on the parallel path

Transfer capability & Transmission capacity – what's the difference?

- **Transmission capacity**
  - Refers to thermal ratings
- **Transfer capability**
  - Refers to the system's capability of transfer-varies considerably with system conditions
  - Can not be arithmetically added for the individual line capacities and ratings
  - Always less than the aggregated transmission interface between two areas



TTC = 315 MVA (Considering N-1 contingency)

Assessment of Transfer Capability

- TTC/ATC assessment is carried out with the help of simulation studies carried out for a representative scenario to arrive at an initial or base case.
- EHV transmission network modelled up to 220 kV level with exceptions for generating units connected at 132 kV and for North Eastern Region, it is modelled down to 132 kV.
- Normally all generating units > 50 MW and connected at 132 kV and above is modelled. Smaller units are lumped for study purpose.
- Loads are generally lumped at 220 or 132 kV, as the case may be.
- Actual data or data as per CEA Transmission Planning Criteria shall be considered.
- The above guidelines are for NLDC/RLDCs. SLDCs may consider lower voltage level and smaller units, if required.

Assessment of Transfer Capability

- Separate base cases calculating the export and import capability corresponding to both peak and off- peak load would be studies.

- **INPUT DATA for Base Case Preparation**
  - Network topology : Network Data from CTU / STUs
  - Unit availability : LGBR/ Updated as per latest OCC
  - Actual Generation : As per past trends/anticipation
  - Actual Demand : As per data furnished/LGBR/past trends
  - MVAR Demand : CEA manual on transmission planning criteria or data furnished

Assessment of Transfer Capability

- **Normal Operating Limit for Line : Thermal Limit**
- **Emergency Limit of the Line: 110 % of Thermal Limit**
- **Normal Operating Limit for ICT: 95% of MVA Rating**
- **Emergency Limit of the ICT: depends on overloading capacity**
- In case of non availability of data/additional data requirement - reasonable assumptions to be made

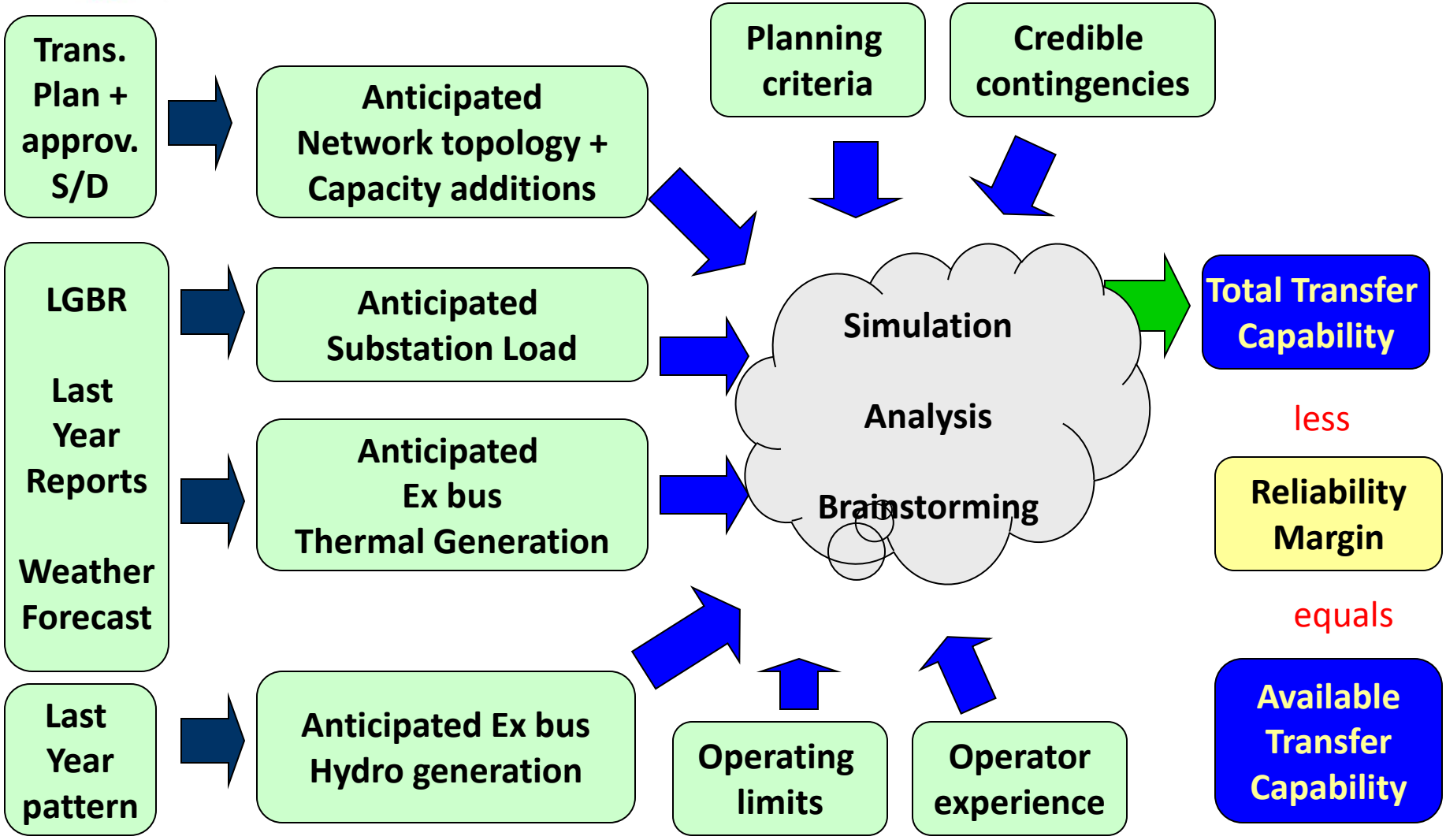
Assessment of Transfer Capability

- Total Transfer Capability between two areas would be assessed by increasing the load in the importing area and increasing the generation in the exporting area or vice versa till the constraints are hit for a credible contingency
- TTC is limited by:
  - Violation of grid voltage operating range OR
  - Violation of transmission element loading limit in n-1 contingency case OR
  - Violation of emergency limit in the n-1 contingency case OR
  - Stability under n-1-1 contingency of a temporary single phase to ground fault on a 765 kV line close to the bus or a permanent single phase to ground fault on a 400 kV line close to the bus OR
  - Angular difference of 30 degrees between adjacent buses under n-1 contingency.

Steady State Voltage Limits

Voltage (kV rms)		
Nominal	**Maximum**	**Minimum**
400	420	380
220	245	198
132	145	122
66	72	60

Transfer Capability assessment



Planning Criteria is strictly followed during simulations

Procedure for TTC/ATC Declaration

- **SLDCs shall assess the TTC/ATC/TRM on its Inter State Transmission corridor considering the meshed intra State corridors for exchange of power with the Inter- State Transmission System (ISTS)**
- **RLDCs shall assess TTC/ATC/TRM for inter-regional corridors at respective ends, intra regional corridors & for individual control areas within the region for a period of three month in advance. TTC, TRM, ATC figures shall be forwarded to NLDC.**
- **NLDC shall assess the TTC, TRM & ATC of inter and intra-regional links/corridors respectively for three month in advance for each month up to the fourth month base on:**
  - **The inputs from RLDCs**
  - **TTC/TRM/ATC notified/considered by CTU for medium-term open access**

Procedure for TTC/ATC Declaration

- **All TTC/ATC declarations to be put on RLDC/NLDC website & also communicated as per Format-I**

- **Revision of TTC/ATC may be done by NLDC based on:**
  - **Commissioning of new transmission lines/generators**
  - **Change in network topology**
  - **Change in anticipated Load/generation**
  - **Based on own observation or from RLDCs/SLDCs inputs**
- **SLDCs / RLDCs / and NLDC shall designate Main and Alternate officers as "Reliability co-coordinator(s)**

Format I for Declaration of TTC/ATC by NLDC

National Load Despatch Centre
Total Transfer Capability for August 2017

Issue Date: 31st July 2017 Issue Time: 1400 hrs Revision No. 5

Corridor	Date	Time Period (hrs)	Total Transfer Capability (TTC)	Reliability Margin	Available Transfer Capability (ATC)	Long Term Access (LTA)/ Medium Term Open Access (MTOA) #	Margin Available for Short Term Open Access (STOA)	Changes in TTC w.r.t. Last Revision	Comments
NR-WR*	1st August 2017 to 31st August 2017	00-06	2500	500	2000	55	1945		
		06-18				65	1935		
		18-24				55	1945		
WR-NR*	1st August 2017 to 06th August 2017	00-24	7050	500	6550	8330	0		Revised STOA margins due to approval of LTA/MTOA by CTU
	07th August 2017 to 31st August 2017	00-24	9050	500	8550	8330	220		
NR-ER*	1st August 2017 to 31st August 2017	00-06	2000	200	1800	193	1607		
		06-18'	2000		1800	303	1497		
		18-24	2000		1800	193	1607		
ER-NR*	1st August 2017 to 31st August 2017	00-24	4500	300	4200	2983	1217		

INCREASING THE ATC

- ✓ Additional Corridors/Modifications of the Network
- ✓ Fixed Series Compensation (FSC)
- ✓ Rescheduling Generation
- ✓ Improving Voltages Profile
- ✓ …….

Declaration of congestion in real-time

- SLDCs/ RLDCs/ NLDC shall have a display available in their web-sites showing TTC, TRM, ATC declared in advance. Format is attached as Format II.

- A corridor shall be considered congested under the following circumstances:
  - Grid voltage in the important nodes downstream/ upstream of the corridor is beyond the operating range specified in the IEGC and/or
  - The real time power flow along a corridor is such that n-1 criteria may not be satisfied.
  - One or more transmission lines in the corridor are loaded beyond the normal limit specified in CEA Manual on Transmission Planning Criteria.

DISPLAY FOR CONGESTION MONITORING

Format II

National/_____Regional Load Despatch Centre

Congestion Monitoring Display

dd/mm/yyyy, hh:mm

Corridor/ Control Area	TTC	ATC	Actual

Declaration of congestion in real-time

- Whenever actual flow on inter/ intra regional link/ corridor exceeds ATC and security criteria above are violated RLDC, NLDC may issue a warning notice
- The format for Notice is given in Format III
- If the power flow on the corridor is as per the schedule, but the congestion has been caused by forced outages of a transmission line in the corridor, which occurs after the drawal schedule has been fixed, then open access transactions shall be curtailed followed by revision of TTC, TRM and ATC.

PROCEDURE FOR REAL TIME CONGESTION DECLARATION

Format III

National/_____Regional Load Despatch Centre

Notice umber: (LDC/RLDC)/yyyy/mm/…. Date: *dd/mm/yy* Time of Issue: *hh:mm*

To

WARNING NOTICE

The actual transfer of electricity on following corridors has crossed the ATC.

Corridor/Control Area	ATC	Actual Flow

The following regional entities, which are downstream of the congested corridor, are advised to reduce their drawl/increase their generation to decongest the system:

1.

…

m.

The following reginal entities, which are upstream of the congested corridor are advised to

/ increase their drawl/reduce their generation to decongest the system:

1.

…

n.

Shift Charge Manager

Declaration of congestion in real-time

- If violation of TTC limits persists for 2 time-blocks not counting the time-block in which warning notice was issued by RLDC and no affirmative action is taken by the defaulting agency, NLDC/ RLDC(s) shall issue a notice for application of congestion charge

- The format for Notice is given in Format- IV

PROCEDURE FOR REAL TIME CONGESTION DECLARATION

Format -IV

National/_____Regional Load Despatch Centre

Notice umber: (LDC/RLDC)/yyyy/mm/…. Date: *dd/mm/yy* Time of Issue: *hh:mm*

To:

NOTICE FOR LEVY OF CONGESTION CHARGE

Congestion charge for Unscheduled Interchange (UI) energy as per CERC (Measures for relieving congestion) Regulations 2009 dated 22nd December 2009 would be applicable w.e.f time block no. (hh:mm)of **dd/mm/yyyy.**

Corridor/Control Area	**TTC**	**Actual Flow**

Congestion charge would be applicable on the following regional entities, which are downstream of the congested corridor:
1. …
m.

Congestion charge would be applicable on the following regional entities, which are upstream of the congested corridor:
1. …
n.

Shift Charge Manager

Applicability of Congestion Charge

- Congestion Charge shall be applicable to Regional entities as per the CERC (Measures to relieve congestion in real time operation) Regulations and orders on rate of congestion charge as applicable from time to time.

- Congestion charge would be levied for
  - over drawal or under-injection in the importing control area and
  - under drawal or over-injection in the exporting control area.

- Shall be applicable only after two time blocks of issue of the notice

- Shall be lifted when power flow falls below ATC and remains below ATC level for at least one time block. Format of the notice is enclosed in Format-V

APPLICABILITY OF CONGESTION CHARGE

Format V

National/_____Regional Load Despatch Centre

Notice Number: (LDC/RLDC)/yyyy/mm/…. Date: dd/mm/yy Time of Issue: hh:mm
To

NOTICE FOR LIFTING OF CONGESTION CHARGE

Congestion charge on Unscheduled Interchange (UI) energy that was applicable w.e.f hh:mm of dd/mm/yyyy vide notice umber.... issued at hh:mm of dd/mm/yyyy would be lifted w.e.f time block no. (hh:mm) of dd/mm/yyyy.

Shift Charge Manager

Transmission Planning Criteria

Transmission Planning Criteria

- Manual on transmission planning criteria was first brought out by CEA in 1985 setting the planning philosophy of **regional self sufficiency**
- The manual was revised in 1994 taking into account the **experience gained on EHV systems**
- **The manual was revised on February 2013 after** incidents of July 2012**.** The transmission planning criteria has also considered large scale integration of renewable energy sources.

Transmission Planning Criteria

- The manual covers
  - the planning philosophy
  - the information required from various entities
  - permissible limits
  - reliability criteria
  - broad scope of system studies
  - modeling and analysis
  - gives guidelines for transmission planning.

Transmission Planning Criteria

- Reliability criteria
  - Criteria for system with no contingency (‘N-0’)
    - The system shall be tested for all the load-generation scenarios
    - For the planning purpose all the equipment shall remain within their normal thermal loadings and voltage ratings.
    - The angular separation between adjacent buses shall not exceed 30 degree.

Transmission Planning Criteria

- Reliability criteria
  - Criteria for single contingency ('N-1')
    - Steady-state :
      - All the equipment in the transmission system shall remain within their **normal thermal and voltage ratings** after a disturbance involving loss of any one of the following elements (**'N-1' contingency**), but without load shedding / rescheduling of generation.
        - » Outage of a 132kV or 110kV single circuit, Outage of a 220kV or 230kV single circuit, Outage of a 400kV single circuit, Outage of a 400kV single circuit with fixed series capacitor(FSC), Outage of an Inter-Connecting Transformer(ICT), Outage of a 765kV single circuit, Outage of one pole of HVDC bipole.
      - The angular separation between adjacent buses under ('N-1') conditions shall not exceed 30 degree.

Transmission Planning Criteria

- Reliability criteria
  - Criteria for single contingency ('N-1')
    - Transient-state
      - The transmission system shall be stable after it is subjected to one of the following disturbances:
        - » The system shall be able to survive a permanent three phase to ground fault on a 765kV line close to the bus to be cleared in 100 ms.
        - » The system shall be able to survive a permanent single phase to ground fault on a 765kV line close to the bus. Accordingly, single pole opening (100 ms) of the faulted phase and unsuccessful re-closure (dead time 1 second) followed by 3-pole opening (100 ms) of the faulted line shall be considered.
        - » The system shall be able to survive a permanent three phase to ground fault on a 400kV line close to the bus to be cleared in 100 ms.

Transmission Planning Criteria

- Reliability criteria
  - Criteria for single contingency ('N-1')
    - Transient-state (Continued)
      - The transmission system shall be stable after it is subjected to one of the following disturbances:
        - » The system shall be able to survive a permanent single phase to ground fault on a 400kV line close to the bus. Accordingly, single pole opening (100 ms) of the faulted phase and unsuccessful re-closure (dead time 1 second) followed by 3-pole opening (100 ms) of the faulted line shall be considered.
        - » In case of 220kV / 132 kV networks, the system shall be able to survive a permanent three phase fault on one circuit, close to a bus, with a fault clearing time of 160 ms (8 cycles) assuming 3-pole opening.

Transmission Planning Criteria

- Reliability criteria
  - Criteria for single contingency ('N-1')
    - Transient-state (Continued)
      - The transmission system shall be stable after it is subjected to one of the following disturbances:
        - » The system shall be able to survive a fault in HVDC convertor station, resulting in permanent outage of one of the poles of HVDC Bipole.
        - » Contingency of loss of generation: The system shall remain stable under the contingency of outage of single largest generating unit or a critical generating unit (choice of candidate critical generating unit is left to the transmission planner).

Transmission Planning Criteria

- Criteria for Simulation and studies
  - System studies for transmission planning
    - The system shall be planned based on one or more of the following power system studies, as per requirements

      i) Power Flow Studies

      ii) Short Circuit Studies

      iii) Stability Studies (including transient stability and voltage stability)

      iv) EMTP studies (for switching / dynamic over-voltages, insulation coordination, etc.)

Transmission Planning Criteria

- Power system model for simulation studies
  - Consideration of voltage level
    - For the purpose of planning of the ISTS:
      - The transmission network may be modeled down to 220kV level (exception for North Eastern Region and parts of Uttrakhand, Himachal and Sikkim - 132kV level)
      - The generating units that are stepped-up at 132kV or 110kV may be connected at the nearest 220kV bus through a 220/132 kV transformer for simulation purpose.
      - The generating units smaller than 50 MW size within a plant may be lumped and modeled as a single unit, if total lumped installed capacity is less than 200 MW.
      - Load may be lumped at 220kV or 132kV/110kV, as the case may be.
    - For the purpose of planning of the Intra-STS System,
      - the transmission network may be modeled down to 66kV level or up to the voltage level which is not in the jurisdiction of DISCOM. The STUs may also consider modeling smaller generating units, if required.

Transmission Planning Criteria

- Power system model for simulation studies
  - Time Horizons for transmission planning
    - Concept to commissioning for transmission elements generally takes **three to five** years; about **three years** for augmentation of capacitors, reactors, transformers etc., and about **four to five years** for new transmission lines or substations.
    - Therefore, system studies for firming up the transmission plans may be carried out with 3-5 year time horizon.

Transmission Planning Criteria

- Load - Generation Scenarios
  - Should reflect the typical daily and seasonal variations in load demand and generation availability.

National Reliability Council for Electricity (NRCE)

National Reliability Council for Electricity (NRCE)

- National Reliability Council for Electricity was constituted on 21.2.2014, which would look into all aspects of reliability of the National Grid.
- Function: Compute TTC of Trans Corridors, Co-ordinate Protection of the grid & Matter related to reliability to the grid

Operational Guidelines for determination of TTC, ATC and TRM for the Short Term Horizon (0-3 Months) of NRCE

➢ Ambient temperature adjusted TTC and ATC

- Ambient temperature over the length of the line may vary somewhat.
- Higher of the maximum temperatures of the two ends of the line will be taken for assessment of TTC, ATC and TRM
- Temperatures will be based on forecast by Indian Metrological Department (IMD) for the next day
- Ampacity of the relevant line may be raised for every 2^0C temperature lower than the ambient of 45^0C, considered as base Ampacity

Operational Guidelines for determination of TTC, ATC and TRM for the Short Term Horizon (0-3 Months) of NRCE

➢ Ambient temperature adjusted TTC and ATC (Cont)

- For example, if there is a 4^0C drop in ambient temperature w.r.t 45^0C, the Ampacity may be raised by 4%.
- Before the increased thermal limit on account of fall in ambient temperature is used, the System Operator may confirm from the owner of the terminal equipment on both sides of the line if **the terminal equipment is capable of carrying the increased current** and also if the **relay settings are in accordance with the same**.

Operational Guidelines for determination of TTC, ATC and TRM for the Short Term Horizon (0-3 Months) of NRCE

➢ Ambient temperature adjusted TTC and ATC (Cont)

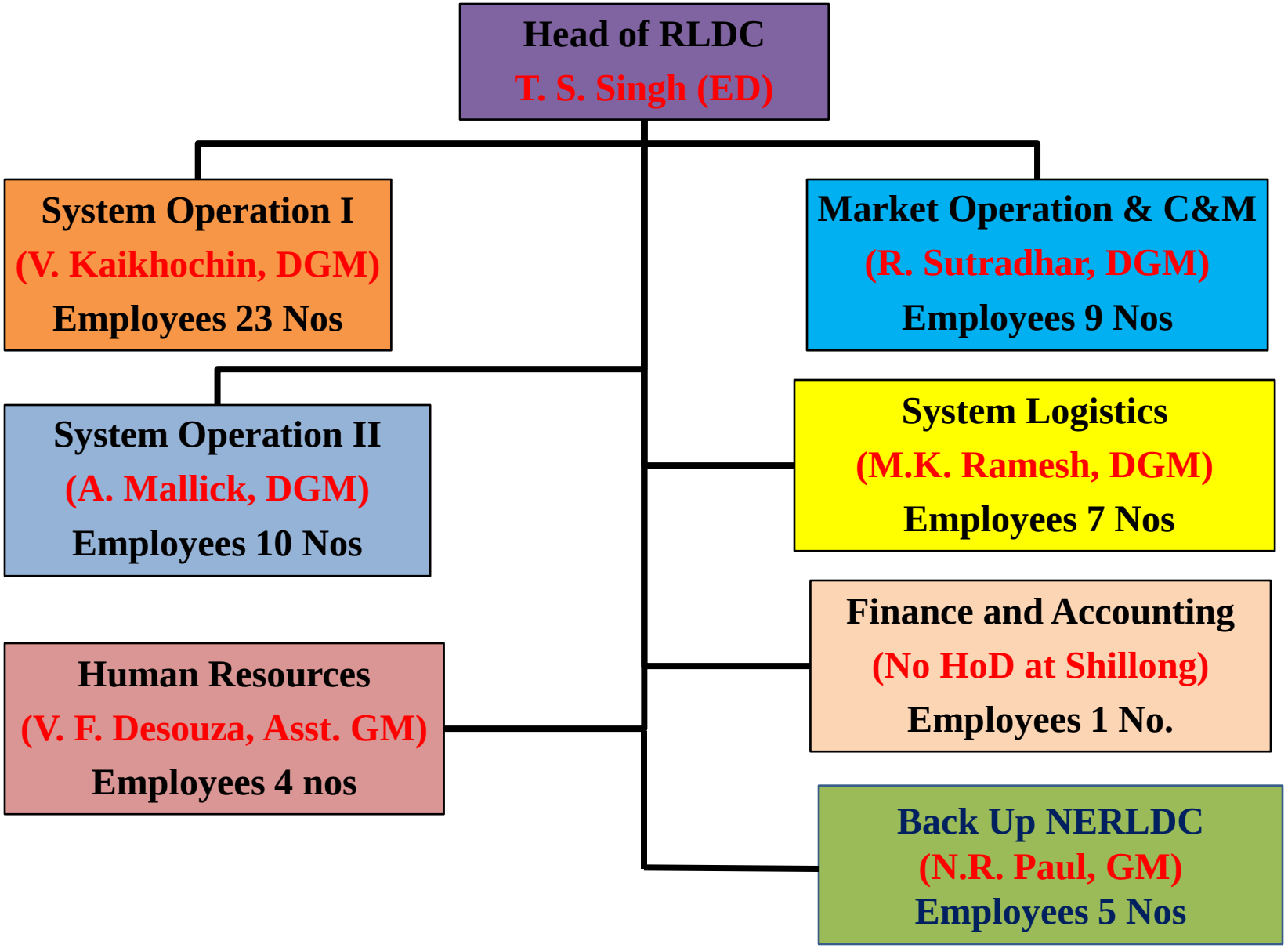
- The confirmation may be done once before the start of the season, i.e. monsoon, winter, etc
- The terminal equipment owners will, on their own, intimate the System Operator when there is an addition to the terminal equipment and its rating
- In case relay settings restrict the transfer of power, it would be checked by the owner of the terminal equipment if they are in line with the guidelines given by the Task Force on Power System Analysis under contingencies
- If they are not in line with the same, the relay settings would have to be aligned with the same.
- The voltage and power factor may be considered for converting ampacity to MW.

Consideration of Special Protection Schemes for the purpose of calculation of TTC and ATC and Emergency loading

- The relay settings of the SPS for carrying out load shedding should be set with such time delay so that the load tripping takes place, considering the **emergency loading limit of the line**, to
- Before the increased thermal limit on account of emergency loading is used, the System Operator may confirm if the terminal equipment is capable of carrying the emergency loading current and also if the relay settings are in accordance with the same to prevent frequent tripping of load.

Thank You

Organization Chart NERLDC



Overview of System Operation-II Department

Introduction

System Operation II mainly deals with:-

- **Pre-Dispatch Planning**
- **Real Time Security Desk**
- **Post-Dispatch Analysis**

Activities of System Operation II

Section I: System Study

- **Studies related to TTC/ATC, Contingency Matrix, Element outage, Synchronization of new elements, Fault level, Transformer Tap optimization etc.**
- **Design of System Protection Schemes (SPS) and Islanding Schemes**
- **Computation of State-wise TTC/ATC**
- **Collection of Input information, Preparation of Base Case for PoC study, checking of PoC Charges and Losses computation**

Activities of System Operation II

Section I: System Study

- **Monitoring of LFO (Low Frequency Oscillations)**
- **Processing of First-time charging of transmission elements**
- **Processing of Start-up power to generator**

Activities of System Operation II

Section II: Protection

- **Event analysis (Based on SCADA, PMU, DR / TFR, EL, SOE, Relay details, etc)**
- **Transmission Availability Certification**
- **Calculation of Reliability Indices (SoPR)**

Activities of System Operation II

Section III: MIS

- **Reporting of Power Supply Position Report, System Status Report, Grid Performance Report ,Quarterly Report etc.**
- **CERC KPI Reports (Frequency Deviation, Voltage Deviation, System Reliability, Grid Disturbance and Grid Incident Reports).**
- **Updating Documents (Operating Procedures, Power Maps, List of Important Grid Elements, Ready Reckoner, State Profile etc.)**

Activities of System Operation II

Section *IV: Real Time Security Desk(RTSD)*

- **Offline System Studies (Outage in real-time, Emergency Shutdown, D-2 Study for OCC Approved Shutdown)**
- **Day Ahead Load Forecast**
- **Reporting of Load Crash due to inclement weather**
- **RTSD Shift Report Preparation & Analysis**
- **Reporting of PMU and SCADA data quality**
- **Monitoring and reporting of LFO in Grid.**

Achievements

- **Based on the Quarterly Feedback to CEA and CTU given by the department, new projects have been executed for system strengthening hence increasing the reliability of NER Grid.**
- **The Protection Issues are now taken up by the Post Dispatch Analysis Group. The suggested remedial measures are being taken up. After installation of Polymer Insulators and TLAs in some lines, tripping has reduced and there has been a decline in number of major Grid Disturbances.**

Protection Audit

The First Phase of Third Party Protection Audit Program was conducted from 31st July'17 to 29th November'17 which audited a total of 69 number of Substations in NER Region.

Major Observations of Audit Team:

- **Primary maintenance of substations except those owned by Central Sector are not up to the mark.**
- **Relay settings need to be reviewed in most of the stations.**
- **Numerical Relays are absent in most of the state owned stations.**
- **Presence of DC Earth Fault is detected in most of the state owned stations.**

Capacity Building for Stake Holders

- **Workshop with Regional Meteorological Center, Guwahati on Weather Portal for Power System.**
- **One Day Workshop on PSSE Software for TTC/ATC calculation & Congestion Regulation for NER Constituents on 16th Feb'17.**
- **Two Day PSSE Training Program for Executives of SLDC Assam was conducted on 24th & 25th Aug'17.**
- **Training Program on System Studies for Executives of SLDC Arunachal Pradesh was conducted on 19th & 20th Feb'18.**
- **PSSE Training has also been imparted to SLDC Manipur via Video Conference.**


Thank
you!