SYSTEM RESTORATION – ISSUES & CHALLENGES

DR.S.ROY BARMAN

WBSETCL

BLACK START-UP PRINCIPLE

- MEANS WHEN THERE IS TOTAL BLACK OUT IN THE GRID.

BROWN START UP PRINCIPLE

- MEANS WHEN THERE IS PARTIAL POWER FAILURE IN THE GRID DUE TO NETWORK CONSTRAINT/POWER PLANT FAILURE.

CAUSES OF GRID COLLAPSE

- SUDDEN LOSS OF GENERATION LEADS TO LOW SYSTEM FREQUENCY & VOLAGE.IF FALLS BELOW PERMISSIBLE LIMITS LEADS TO SYSTEM COLLAPSE.
- WIDE MISMATCH IN BETWEEN GENERATION & DEMAND.
- RAMPANT TRIPPINGS IN DIFFERENT GRID SUBSTATIONS & ISOLATION OF SUBSTATIONS FROM THE GRID.
- SUDDEN OCCURRENCE OF TRNASMISSION CONSTRAINTS DUE TO TRIPPING OF LOADED LINE/LINES LEADS TO POWER SWING DUE TO WIDE RANGE LOAD ANGLE VARIANCE.

CAUSES OF GRID COLLAPSE

- LOW VOLTAGE IN A PARTICULAR LOCATION DUE TO HIGH INDUCTIVE VAR DRAWAL BY MOTORS & ABSENCE OF CAPACITIVE OR LEADING VAR SUPPORT LEADS TO VOLTAGE COLLAPSE.
- DELAYED CLEARANCE OF SYSTEM FAULT DUE TO FAULTY PROTECTION EQUIPMENTS & C.B LEADS TO SEVERE VOLTAGE DIP & DELAYED TRIPPING OF FAR ENDED LINES/PULL OUT OF GENERATORS.
- FAILURE OF SCADA SYSTEM WHICH LEADS TO WRONG INDICATION OF C.B STATUS & RIGHT DECISION MAKING PROBLEM.
- HUMAN ERROR IN SYSTEM OPERATION.

CAUSES OF GRID COLLAPSE

- ABSENCE OF PREVENTIVE MAINTENANCE OF ELECTRICAL EQUIPMENTS SPECIALLY TRANFORMERS,LINES,CT,PT,LIGHTNING ARRESTORS,CBS & REGULAR CALIBRATION OF METERS & PROTECTIVE EQUIPMENTS.
- LACK OF COMPETENT TECHNICAL EXPERT FOR SYSTEM CONTROL.
- DUE TO AGE OLD LINES,CBS,PROTECTIVE EQUIPMENTS ETC WHICH ARE BEYOND REPAIR.

OBJECTIVE OF RESTORATION PLANNING

- HARNESS START UP POWER FROM BLACK START POWER PLANTS.
- EXTEND SURVIVAL POWER TO ALL THERMAL UNITS & START UP POWER TO AT LEAST ONE SINGLE UNIT FOR EACH POWER PLANT FOR EARLY SYNCHRONISATION OF UNIT.
- TO SYNCHRONISE HYDEL UNITS FROM READILY AVAILABLE INPUT I.E WATER.

OBJECTIVE OF RESTORATION PLANNING

- EARLY RESTORATION OF ESSENTIAL LOADS.
- IN SUBSEQUENCE RESTORATION OF NORMAL LOAD AS EARLIEST AS POSSIBLE.
- ESTABLISHMENT OF ALL TIE LINES & INTERCONNECTIONS.
- RESUME EXPORT/IMPORT ALREADY COMMITTED.
- RESUME MERIT ORDER LOAD DESPATCH.

CONSTRAINTS REGARDING RESTORATION PLANNING

- TIME OVER RUN FOR SWITCHING OPERATIONS.
- DELAYED SYNCHRONISATION OF THERMAL UNITS.
- HIGH VOLTAGE PROBLEM DUE TO LIGHTLY LOADED LINES.
- ABNORMAL FREQUENCY RESPONSE OF PRIME MOVERS DUE TO SUDDEN LOAD PICK UP.

CONSTRAINTS REGARDING RESTORATION PLANNING

- WIDE VARIATION OF INCOMING LOAD ASSOCIATED WITH POWER FACTOR & DEMAND FACTOR.
- PROBLEM REGARDING AVAILABILITY OF GOVERNOR FACILITIES OF UNITS.

KNOWLEDGE BEFORE HAND FOR SYSTEM RESTORATION

- THE MAGNITUDE OR EXTENT OF BLACKOUT.
- ASSESS THE BOUNDARIES OF AN ENERGISED AREA IF ANY.
- KNOWLEDGE REGARDING FREQUENCY & VOLTAGE OF THE SURVIVED AREA/AREAS.
- HOT OR COLD STATUS OF GENERATING UNITS.
- STATUS OF CBS.

GUIDE LINES OF BLACK START AS PER INDIAN ELECTRICTY GRID CODE(IEGC)

- DETAILED PLANS & PROCEDURES FOR RESTORATION OF THE REGIONAL GRID UNDER PARTIAL/TOTAL BLACKOUT SHALL BE DEVELOPED BY RLDC IN CONSULTATION WITH ALL REGIONAL CONSTITUENTS/RPC SECRETARIET & SHALL BE REVIEWED /UPDATED ANNUALLY.
- DETAILED PLANS & PROCEDURES FOR RESTORATION AFTER PARTIAL/TOTAL BLACKOUT OF EACH CONSTITUENT'S SYSTEM WITHIN A REGION,WILL BE FINALIZED BY THE CONCERNED CONSTITUENT IN COORDINATION WITH THE RLDC.THE PROCEDURE WILL BE REVIEWED,CONFIRMED AND/OR REVISED ONCE EVERY SUBSEQUENT YEAR.MOCK TRIAL RUNS OF THE PROCEDURE FOR DIFFERENT SUB-SYSTEMS SHALL BE CARRIED OUT BY THE CONSTITUENTS AT LEAST ONCE EVERY SIX MONTHS UNDER INTIMATION TO THE RLDC.
- LIST OF GENERATING STATIONS WITH BLACK START FACILITY,INTER-STATE/INTER-REGIONAL TIES,SYNCHRONIZING POINTS & ESSENTIAL LOADS TO BE RESTORED ON PRIORITY,SHALL BE PREPARED & BE AVAILABLE WITH RLDCS.

GENERAL CRITERIA – METHODOLOGY TO BE FOLLOWED IN CASE OF GRID COLLAPSE

- ALDC/SLDCS SHOULD INFORM THE POWER STATIONS WHO HAVE BLACK START FACILITIES TO TAKE IMMEDIATE ACTION.
- ALDC/SLDCS SHOULD INFORM THE CHIEF OF SYSTEM OPERATION & CHIEF OF COMMUNICATION ABOUT THE SEVERITY OF COLLAPSE.

- WHILE CHOOSING THE PATH FOR START-UP POWER,220 KV & ABOVE LINES ARE TO AVOIDED AS FAR AS POSSIBLE TO AVOID OVER VOLTAGE.
- FOR EXTENDING START UP POWER 132 PATH SHOULD BE CHOSEN AS FAR AS POSSIBLE TO AVOID OVER VOLTAGE.
- MINIMUM NUMBER OF SECTIONS IN 132 KV ARE TO BE CHOSEN TO AVOID COORDINATION & SWITCHING PROBLEM.
- IF REQUIRED,LOAD IS TO BE RELEASED IN A CO-ORDINATE MANNER AS FAR AS POSSIBLE AT INTERMEDIATE SUB-STATIONS TO ARREST OVER-VOLTAGE,IF ANY.
- TO AVOID UNBALANCING,PHASE BALANCING SHOULD BE KEPT IN VIEW IF TRACTION LOAD IS RELEASED.
- GENERATOR LOADING WHICH IS SUPPLYING START-UP POWER SHOULD BE CHECKED & TOTAL LOADING SHOULD NOT CROSS 80% OF ITS CAPACITY.EFFORTS SHOULD BE MADE TO KEEP THE GENERATOR OPERATING TO LAGGING SIDE,IF NOT POSSIBLE AT LEAST TO NEAR UNITY POWER FACTOR.
- THERMAL STATIONS SHOULD BE PROVIDED SURVIVAL POWER AS EARLY AS POSSIBLE TO AVOID DAMAGE TO THE EQUIPMENT IN CASE OF D.C FAILURE (E.G. BARRING GEAR,LUB OIL,SEAL OIL,COMPRESSOR FOR CIRCUIT BREAKERS,VALVES,PNEUMATIC INSTRUMENTS ETC.).

- OPERATOR SHOULD BE ABLE TO DISTINGUISH BETWEEN START-UP & SURVIVAL POWER.
- AUXILIARY POWER SHOULD BE RELEASE IN STEPS SO THAT ALL THE RUNNING UNITS COULD BE STARTED GRADUALLY.
- NO. OF ISLANDS FORMED TO BE CHECKED TO AVOID ANY MIS-SYNCHRONISATION.
- CHECK THE SUB-STATIONS WHICH HAVE SYNCHRONISING FACILITIES IN PROPER WORKING ORDER/CAPABILITIES (IF IT APPREHENDED THAT DUE TO CONTINUOUS INTEGRATED OPERATION,OPERATING PERSONNEL HAVE LOSTTHE EXPERIENCE OF SYNCHRNISING THE LINES IN MOST OF THE SUB-STATIONS).ROUGH SYNCHRONISATION SHOULD BE AVOIDED AS SMALL SYSTEM MAY NOT BE ABLE TO TAKE THE JERK.
- CHECK HOW MANY UNITS WERE RUNNING IN EACH POWER STATION BEFORE COLLAPSE TO ASSESS THE START-UP POWER REQUIRED.
- IN ORDER TO INCREASE SPINNING RESERVE IN HEALTHY SYSTEM,IF REQUIRED SHEDDING SHOULD BE DONE IN ISLANDS WHICH HAVE SURVIVED.
- SHIFT PERSONNEL SHOULD BE RETAINED TILL THE RESTORATION IS COMPLETED BEFORE HANDING OVER CHARGE TO NEXT SHIFT.
- AREA LOAD DESPATCH CONCEPT SHOULD BE ADOPTED DURING START-UP TO AVOID JAMMING OF COMMUNICATION SYSTEM AS WELL AS DECISION MAKING.
- THE START-UP PROCEDURE SHOULD BE KNOWN TO EVERY ONE & WORKING LEVEL PERSONNEL SHOULD DO IT WITHOUT REFERENCE OR WAITING FOR MANAGEMENT'S CONSENT DURING THE CRISIS.

- MAXIMUM TIME FOR WHICH SUPPORT SHOULD BE PROVIDED TO THE COLLAPSED SYSTEM SHOULD BE DOCUMENTED TO A USE OF START-UP POWER FOR OTHER PURPOSE.
- WHILE DURING NORMAL TIME IT IS 400/220 KV SUPER GRID WHICH IS MONITORED,DURING START-UP PHASE IT IS 132 KV NETWORK WHICH NEEDS TO BE KNOWN AND HENCE THE KNOWLEDGE OF 132 KV NETWORK IS ESSENTIAL AND INFORMATION REGARDING THE AVAILABILITY OF PARTICULAR SECTION AT THAT TIME BE MADE KNOWN TO SLDC.
- POWER PLANT SHOULD ALSO BE KEPT INFORMED SO THAT THEY CAN DIFFERENTIATE BETWEEN FULL AUXILIARY POWER TO START ALL THE RUNNING MACHINES;MINIMUM AUXILIARY POWER TO START MINIMUM NUMBER OF MACHINES;SURVIVAL POWER TO AVOID DAMAGE TO THE PLANT AND DO PREPARATORY WORK FOR START.
- IF POSSIBLE GAS TURBINE PLANTS SHOULD BE RUN TO PROVIDE START-UP POWER AND TO CONTROL VOLTAGE,IF REQUIRED REDUCING MW LOADING AND SHARING MVAR DEPENDING ON VOLTAGE.
- CONSTITUENT WISE PRIORITIES OF LOAD WHICH IS TO BE CONNECTED IN STEPS SHOULD BE DOCUMENTED AND WHILE RELEASING LOADS FOR EXAMPLE,TRACTION LOADS,UNDERGROUND COAL MINES/DEEP GASSY MINES/AIR/TV/TELEPHONE EXCHANGE/HOSPITAL,PUMPING STATION ETC. SHOULD BE GIVEN PRIORITY DEPENDING ON AVAILABLE GENERATION.

- PRIOR CO-ORDINATION WITH RAILWAYS IS TO BE DONE TO CO-ORDINATE SHIFTING OF LOADS BY RAILWAYS BETWEEN RAILWAY FEEDING POINTS.
- ALL THE MEASURING INSTRUMENTS WILL SHOW BELOW SCALE.MW SHOULD BE UNDERSTOOD BY EVERYONE BY SEEING CURRENT ONLY.FOR 132 KV LINES WHERE CT RATIO IS LOW IT MAY NOT ALWAYS BE POSSIBLE TO NOTE CURRENT.
- ONE-DAY APPRECIATION COURSE FOR START-UP PROCEDURE SHOULD BE ORGANISED AT REGIONAL LEVEL FOR THE FOLLOWING :
- TOP MANAGEMENT.
- CHIEF LOAD DESPATCHER.
- LOAD DESPATCH PERSONNEL.
- POWER STATION OPERATOR.
- SUB-STATION OPERATOR.
- TAP POSITION OF STATION TRANSFORMERS,BUS VOLTAGE,FREQUENCY ETC.IN THE POWER STATION SHOULD BE CAREFULLY MONITORED TO SEE THAT OVER FLUXING DO NOT OCCUR WHEN EFFORTS ARE ON TO BRING THE UNIT BACK.

- THE RESTORATION MANUAL SHOULD BE UPDATED AFTER EVERY ADDITION OF POWER SYSTEM ELEMENTS AND SHOULD BE THROUGHLY REVISED AFTER EVERY COLLAPSE.
- TO CONTROL OVER-VOLTAGE,FOLLOWING MAY BE CONSIDERED AS PER REQUIREMENT OF SITUATION :
- START SYNCHRONOUS CONDENSER WHEREEVER AVAILABLE.
- KEEP GTS RUNNING.
- BACK CHARGING FROM 132 KV SIDE OF TRANSFORMER WITHOUT LOADING THE SAME AS REACTOR TO AVOID OVER VOLTAGE.
- 132/33 KV TRANSFORMER.
- 132/220 KV AUTO TRANSFORMER.
- 220/400 KV AUTO TRANSFORMER.
- 400 KV BUS REACTOR,IF REQUIRED BY TAP-CHANGING.

- THE FOLLOWING 132 KV LINES WHICH ARE NORMALLY KEPT OFF IN EASTERN REGION MAY BE REQUIRED TO BE USED DURING START-UP PROCEDURE.THE LINES,THEREFORE,SHOULD BE TESTED ONCE IN A MONTH FOR ITS HEALTHINESS.THE COMMUNICATION BETWEEN THE CONCERNED STATIONS SHOULD BE KEPT HEALTHY.
- JODA-KENDPOSI 132 KC S/C (GRIDCO/BSEB).
- PURULIA-PURULIA 132 S/C(DVC/WBSETCL).
- MAITHON-DEOGHAR 132 S/C(DVC/BSEB).
- ROURKELLA-GOELKERA 132 KV S/C(GRIDCO/BSEB).
- RIHAND-GARWA 132 KV S/C (UPSEB/BSEB).
- RIHAND-SONENAGAR 132 S/C(UPSEB/BSEB).
- SAHUPURI-KARMANASA 132 D/C(UPSEB/BSEB).
- RAMGARH-PATRATU 132 S/C(DVC/BSEB).
- PURNEA-DALKHOLA 132 S/C(BSEB/WBSETCL).
- WARIA-DPL 132 KV D/C(DVC/DPL).
- A LIST OF DOT TELEPHONE NOS. OF ALL THE SUB-STATIONS WITH STD CODE SHOULD BE AVAILABLE AT PLANT AND AT SLDC/RLDC AS COMMUNICATION IS THE ESSENTIAL REQUIREMENT DURING THE RESTORATION PROCESS.
- BEFORE ASKING POWER STATION TO DRAW START-UP POWER,THE CAPACITY OF ISLAND TO SUSTAIN THE STARTING CURRENT OF BIGGEST INDUCTION MOTOR(GENERALLY BFP) SHOULD BE CHECKED. APPROXIMATE FAULT LEVEL MAY BE RECALCULATED FOR THE PURPOSE.

GENERATOR SIZE	TYPICAL LARGEST MOTOR SIZE
500 MW THERMAL	10000 KW
210 MW THERMAL	4000 KW
140 MW THERMAL	2475 HP
120 MW THERMAL	2370 HP
110 MW THERMAL	2145 HP
60 MW THERMAL	1020 KW
80 MW HYDEL	250 HP COOLING WATER

- PRIORITY SHOULD BE ATTACHED TO PROVIDE SUPPORT POWER TO CAPTIVE UNITS IN CASE THEY SO REQUEST & VICE-VERSA.
- THE RESTORATION PROCESS IS EASIER TO UTILITIES WHICH ARE CENTRALLY SITUATED WITH LARGE NUMBER OF INTERCONNECTION,BUT REQUIRES MORE CO-ORDINATION WITH NEIGHBOURING UTILITIES & RLDC.SUCH ORGANISATION HAS TO BE SPECIALLY PREPARED DURING START-UP PROCEDURE.
- POWER STATIONS LIKE CHUKHA,BALIMELA WHICH ARE SITUATED ON THE PERIPHERY HAVE VERY LITTLE OPTION OF AVAILING START-UP POWER UNLESS NEIGHBOURING REGION ASSISTS E.G. NEREB/ASEB (IF WBSETCL SUPPLY IS NOT AVAILABLE) & SREB/APSEB.
- AT THE EARLY STAGE OF RESTORATION (IN CASE OF BLACK START) WHEN THE ISLANDS ARE BEING ESTABLISHED.THE ROLE OF RLDC/SLDC IS ONLY ADVISORY & CO-ORDINATING.CONTROL OF THE ISLAND WILL BE FROM THE POWER STATION OR A NOMINATED SUB-STATION OR A AREA LOAD DESPATCHER BUT SLDC/RLDC SHOULD KNOW ABOUT THE ISLANDS & ITS GENERATION.
- THE RLDC/SLDC WILL TEND TO ASSUME ITS NORMAL ROLE WHEN SIGNIFICANT ISLANDS ARE TO BE REPARALLED.
- IT IS FELT THAT THERE IS A NEED FOR A STRATEGY OF RESTORATION TO BE AVAILABLE RATHER THAN DETAIL.DETAILS WITH 1^{ST} ,2^{ND} & 3^{RD} ALTERNATIVE MAY BE DRAWN UP BY EACH CONSTITUENTS UNDER INTIMATION TO ERPC & ERLDC.

- TRAINING SHOULD BE AN INTEGRAL PART OF OPERATOR'S DUTY WHICH COMPRISES OF :
- A BASIC CONTROL ROOM OPERATOR COURSE FOR NEW ENTRANTS.
- ROUTINE DISCUSSION E.G.O.C.C;SEMINAR ETC.
- YEARLY TALK BY SPECIALISTS ON PROTECTION & RESTORATION.
- IT SHOUD BE AN ESTABLISHED PRACTICE IN BLACK START SITUATION TO OPEN CIRCUIT BREAKERS SO AS TO ESTABLISH A WELL DEFINED STARTING POINT FOR RESTORATION.
- CONDITION OF DC SUPPLY SOURCE BATTERY/D.G SET SHOULD BE CHECKED AT LEAST ONCE IN A MONTH.
- IN THE POWER STATION AND SUB-STATION WHERE IT IS POSSIBLE TO REGULATE THE VOLTAGE.A CHART MAY BE KEPT INDICATING THE FREQUENCY AND CORRESPONDING MAXIMUM VOLTAGE TO CAUSE OVERFLUXING.
- FOR EXTENDING START-UP POWER FROM ONE CONSTITUENT TO ANOTHER,CLEAR AUTHORITY SHOULD BE GIVEN TO SLDC/CLD INDICATING CLEARLY THE LINE THROUGH WHICH SUCH START UP POWER IS TO BE EXTENDED.CONCERNED SLDC/CLD SHOULD BE EMPOWERED TO RESORT LOAD SHEDDING OR TO BRING UP GENERATION WHEREEVER POSSIBLE TO EXTEND START UP POWER TO NEIGHBOURING CONSTITUENTS DURING ANY CRISIS.IF THERE IS PROVISION TO EXTEND START UP POWER TO OTHER CONSTITUENTS THROUGH MORE THAN ONE TIE LINE,PRIORITY SHOULD BE DECIDED.IF THERE IS POSSIBILITY OF EXTENDING START UP POWER FROM ONE SPECIFIC STATION TO TWO OR MORE CONSTITUENTS.PRIORITY AND QUANTUM SHOULD BE SPECIFIED E.G JODA-JAMSHEDPUR(DVC),JODA-RAMCHANDRAPUR(BSEB),JODA-KENDPOSI(JSEB).

- RLDC/SLDC SHOULD ASSUME BIGGER ROLE AND PROVIDE GUIDELINES FOR PROPER UTILISATION OF AVAILABLE RESOURCES.
- GENERAL PRINCIPLES FOLLOWED WHILE FORMULATING THE RESTORATION PLANS FOR INDIVIDUAL POWER STATIONS :
- CASE (A) : TOTAL COLLAPSE OF THE CONSTITUENT SYSTEM IN WHICH THE POWER STATION IS LOCATED – PRIORITY WISE SOURCES IDENTIFIED IN NEIGHBOURING SYSTEMS,FROM WHICH POWER CAN BE EXTENDED TO THE CONCERNED POWER STATION.
- CASE (B) : TOTAL BLACK OUT OF THE INDIVIDUAL POWER STATION ONLY-THE FIRST PRIORITY OF AVAILING ASSISTANCE SHOULD BE FROM THE OTHER PART OF THE CONSTITUENT IN WHICH THE STATION IS LOCATED.IN CASE THIS IS NOT POSSIBLE,ASSISTANCE SHOULD BE AVAILED FROM THE NEIGHBOURING SYSTEM.HOWEVER,THE ABOVE PRIORITY MAY CHANGE,DEPENDING UPON STATION SPECIFIC FACTORS/ADVANTAGES.
- CASE (C) : TOTAL COLLAPSE OF THE REGIONAL GRID E.G. EASTERN REGION – ASSISTANCE FROM OUTSIDE REGIONS HAS ALSO BEEN CONSIDERED FOR BSEB,JSEB & GRIDCO SYSTEMS,BY VIRTUE OF THEIR GEOGRAPHICAL POSITIONS.

SOME DON'TS

- DO NOT LOAD LINES BEYOND 80% CAPACITY.
- DO NOT HASTILY CONNECT LOADS AND DO NOT ALLOW FREQUENCY TO COME BELOW 50 HZ IN ANY CASE.THE CASE OF ANY SURVIVING ISLAND OR EVEN UNIT WITH HOUSE-LOAD SHOULD BE INFORMED TO ALL.
- ONCE POWER IS EXTENDED TO A POWER STATION/CONSTITUENTS,IT SHOULD NOT BE DISCONNECTED EXCEPT EMERGENCY AS ALL ACTIONS TAKEN BY THE POWER STATION HAVE TO BE REDONE.
- TILL THE RESTORATION PROCESS IS OVER,SLDC/RLDC SHOULD NOT BE DISTURBED IN ANY WAY FOR WORKING AS MANAGEMENT INFORMATION SYSTEM.
- NO COMMERCIAL PROBLEM SHOULD BE BROUGHT UP FOR EXTENDING POWER DURING RESTORATION PROCESS.
- COMMUNICATION LINKS SHOULD NOT BE MADE UNNECESSARILY BUSY DURING START-UP PROCESS.DURING ANY CRISIS SLDC/RLDC ARE EXPECTED TO BE BUSY.

LIST OF POWER STATIONS/SUB-STATIONS HAVING SYNCHRONISING FACILITY

- IN CASE OF WBPDCL : BANDEL,SANTALDIH,KOLAGHAT,BAKRESWAR,SAGARDIGHI.
- IN CASE OF WBSEDCL & DPL : JALDHAKA,RAMMAM,TCF,PPSP & DPL.
- IN CASE OF CESC : BUDGE-BUDGE,TITAGARH,BELUR/LILUAH,SOUTHERN,HOWRAH(ANDUL).

STATUS OF D.G SETS FOR RESTORATION OF AUXILIARY POWER AT WBSEDCL/PDCL POWER PLANTS

POWER PLANT	CAPACITY
BTPS	NOT AVAILABLE
STPS	700+730 KVA
KTPS	2X1 MVA
BKTPS	2X1250 KVA
SGTPS	NOT AVAILABLE
JHP/RHP/TCF	200+230/2X310/3X380 KVA
PPSP	760 KVA

PRECAUTIONERY MESURE TO BE TAKEN TO AVOID GRID COLLAPSE

- Addition of generation i.e continuous capacity additions commensurate with projected load growth and for 1% LOLP (Loss Of Load Probability) and 14% reserve capacity is to be done to prevent/overcome shortage of generation ,addition of new generation capacity has to be planned corresponding to estimated load growth and the factors of LOLP and reserve capacity to meet peak demand.
- Commissioning of fast acting protection schemes i.e fast and reliable protection schemes based on cutting edge technology like numerical relays along with carrier inter-trip schemes are to be commissioned on all the new lines , besides replacing the existing old (life time served) relays and switchgear for ensuring fast clearance of faults in the EHV Network.Single phase,single shot auto-reclosure shall also be commissioned along with carrier inter-trip on all EHV transmission lines,which improves system stability.

- As per IEGC, approved by CERC,the nominal,maximum & minimum voltages shown in TABLE – 1 also the fault clearance times for a three phase fault (close to the busbars) shall not be more than i) 100 milli seconds for 800 kv & 400 kv; ii) 160 milli seconds for 220 kv & 132 kv.
- Backup protection is to be provided for required isolation in the event of failure of primary protection systems.

- Maintaining better voltages i.e unlike frequency which is the same throughout the region,voltages vary at every node.low voltages occur due to :
- - predominantly reactive loads which consume reactive power;
- - inadequate capacitive compensation;
- - overloading of transmission lines because lines consume reactive power above their surge impedance loading level.
- The problem of low voltages can be encountered by :
- - installing capacitor banks mainly at load points;
- - controlling the reactive power flow on the EHV transmission lines by installing dynamic SVCS(Static Var Compensators) and going for FACTS(Flexible AC Transmission Systems).

- By controlling reactive power & voltage control as per IEGC bulk tariff scheme i.e the beneficiaries are expected to provide local VAR compensation/generation such that they do not draw VARS from the EHV Grid.However,considering the present limitation , this is not being insisted upon.instead,VAR drawals by beneficiaries (except on their lines emanating from ISGS) are to be priced as follows :
- - the beneficiary pays for VAR drawal when voltage at the metering point is below 97%.

- - the beneficiary gets paid for VAR return when voltage is below 97%.
- - the beneficiary gets paid for VAR drawal when voltage is above 103%.
- - the beneficiary pays for VAR return when voltage is above 103%.
- The remedial measures mentioned above involve huge capital investment and require long gestation period.Power system planning and implementation needs a consistent and continuous investments,proportional to the load growth to have a stable and reliable system to serve the consumer better.

TABLE-1:REFERENCE VOLTAGES AS PER IEGC

NOMINAL(KV)	MAXIMUM(KV)	MINIMUM(KV)
400	420	360
220	245	200
132	145	120

CONCLUSIONS

- ISTS (Inter State Transmission System) shall be capable of withstanding and be secure for following contingencies without necessitating load shedding or rescheduling of generation during steady state operation.
- Over voltage relay should be introduced in 220 & 132 KV systems like 400 KV system to avoid LA failure during system restoration & taking corrective measure by load management.
- Paradigm shift in system operation i.e transition from peaceful to war like situation.Less time should be taken for system restoration to avoid more chaotic situation.Both are inversely proportional to each other.

- A good knowledge of network is must for a load despatcher for early restoration of grid.
- Load angle should be checked from online load flow study.
- HVDC link & Cable charging should be avoided during restoration.
- Clear idea on islanding schemes should have to prevent total failure.Restoration work of islanding schemes should be done carefully. If it require take ample time to avoid further grid collapse.
- Involve most competent person without taking into consideration designation,qualification & seniority for early restoration of grid.

- Encourage the persons through citation or acknowledgement those who restored grid.
- Details of network,contact details of key persons should be upgraded at a regular interval for early restoration of the system.
- From planning stage grid restoration plan should be considered.
- Power trading will be allowed keeping stability of the system.
- SCADA should operate in true sense as faulty system i.e wrong showing of C.B on/off status may cause grid failure.

- Frequent telephone calls from higher officials to load despatchers during restoration process should be avoided to avoid further trouble in the system.
- Due to single phase load,full load to traction feeders will be allowed after synchronisation of a few units to avoid negative sequence associated problems.
- Power failure is high impact but low probability main concern for the system.
- Volage & Reactive Management : ensure sufficient voltage support for reliable operations.
- Reliability of communication system : review,and as necessary strengthen,communication protocols between Sub-Stations,ALDCS,SLDCS, RLDCS & NLDC.

- Post analysis after disturbance is easier task compared to restoration of grid by load despatchers at the earliest.
- Failure of system monitoring & control functions : review & as necessary,establish a formal means to immediately notify control room personnel when SCADA or EMS functions,that are critical to reliability,have failed & when they are restored.
- After restoration written report should be given to media as early as possible to avert gossip,foolish comments.

- Emergency action plans : ensure that emergency action plans & procedures are in place to safe guard the system under emergency conditions by defining actions operators may take to arrest disturbances & prevent cascading.
- As the time elapsed to restore grid invites more load, accordingly cold load pick up model should be designed.Be cautious about incoming load which may cause system failure.
- Training for emergencies : ensure that all operating staff are trained & certified,if reuired,& practice emergency drills that include criteria for declaring an emergency,prioritized action plans,staffing & responsibilities,& communications.

- Pump storage / Hydel schemes should be utilised as a black start facility during system restoration.
- Vegetation Management : ensure high voltage transmission line rights of way are free of vegetation & other obstructions that could contact an energised conductor within the normal & emergency ratings of each line.
- Joint team comprising of RLDC & SLDC Personnel make surprise visit once in a three months on regular basis to black start plants regarding healthiness of the emergency supply units.
- Over current settings,negative sequence problem while restoring traction load,over flux problems,under excitation operation of synchronous generators should be studied & checked in details during steady state operation of the system.

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