उत्तर क्षेत्रीय ग्रिड-प्रणाली पुर्नस्थापन प्रक्रिया

SYSTEM RESTORATION PROCEDURES FOR NORTHERN REGION

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Preface

Indian Power system is growing rapidly. It plays an important role in economic growth of the country. Power system network is witnessing phenomenal changes and new power system elements are added to the network at quick intervals. Under these conditions operating and maintaining the grid in a satisfactory manner is a challenge.

In order to deal with contingencies like partial or total black out in the Northern Region, NRLDC is regularly updating the document called "System Restoration Procedure for Northern Region" in line with provision in section 5.8 of the Indian Electricity Grid Code (IEGC). The revised version of system restoration procedure is in front of you. This procedure is revised in consultation with the constituent members of Northern Region grid.

Chapter-1 of this procedure deals with the Restoration Strategies and General Guidelines during restoration. As no two grid disturbances are similar, the contents of this chapter are very useful for handling any contingency.

Chapter-2 of this procedure gives overview of northern region system restoration procedure. Based on geographical boundaries and for ease and speedy restoration, northern region power system is divided into four sub-systems namely Eastern UP, North-Central, Rajasthan and Western UP/ Uttarakhand sub-system.

Chapter-3 to Chapter-6 of this procedure gives detail description of restoration procedure in each sub-system. For easy reference these four chapters has been divided into following sub-sections: Sub-system overview, Sub-System Restoration Procedure, Sub-System synchronization and Restoration stages and start-up sequence in a sub-system.

Chapter-7 of this procedure gives detail description of handling Railway traction supply in the northern region.

Chapter-8 and Chapter-9 of this procedure gives guidelines to be followed at HVDC back to back stations at Vindhyachal and Sasaram.

In addition to these nine chapters, seven annexure have been added at the end of this procedure for quick accessibility of power maps, generator locations, reactive power management tools, and Fault level and line parameters.

We are sure that this revised version of "System restoration Procedure for Northern Region" would be helpful in dealing with any contingency in the region. All efforts have been made to make this book error free and up to date. However, in view of the fast changing network conditions, it is possible that some of the changes could have not been incorporated as per actual. Any feedback from the users of the book is most welcome as it will help us to improve the overall quality, style and presentation of the book in future.

System Restoration Procedure for Northern Region

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Generating Station Index

Chapter-1: Restoration Strategies and Guidelines

1.1. Blackouts

A total power failure over a large area usually caused by the failure of major generating equipment or transmission facilities. The possible causes of blackouts identified from literature survey and from review of past incidents are as listed below:

- Fault at a focal point in the grid
- Delay in fault clearance
- Tripping of large generating units
- Cascade tripping of transmission line(s) resulting from tripping of a heavily loaded transmission line
- Cascade tripping of ICT's due to overloading
- Equipment failure
- Protection mal-operation
- Slow response of generating units
- Slow response of manual load shedding during low frequency
- Inclement weather (heavy rainfall, fog, dust storm etc.)
- Inadequate reactive reserves leading to voltage collapse
- Inadequate safety net in the form of under frequency, Under Voltage, Rate of Change relay load shedding,
- Human error
- Combination of above events

1.2. Restoration Strategies

Grid disturbance can occur in the grid due to several reasons. Each one is unique in its characteristics and impact. It would be difficult to prescribe a single solution that fits all scenarios. However the general philosophy and guidelines for system restoration elaborated in this document may be useful in reducing the restoration time in effective manner.

The restoration activities following a blackout have been divided into following broad categories.

a) Formation of sub-systems

Following a blackout the system should be restored systematically. For this purpose each sub-system is designed to have:

1 Units with adequate black start capability (i.e., hydro units, gas turbines etc.) to provide start-up power to remaining generating facilities within the sub-system and to supply power to critical loads.

2 Sufficient generation to supply most of the load within the sub-system.

b) Restoration of individual sub-systems

Immediately after a blackout, the operators in the blackout area shall open all circuit breakers and restart the black start unit in the respective subsystem. The operators would then make efforts to establish a path between the self-started units and other thermal/ hydro units, which require offsite startup power. Along the path, some critical loads would be restored for stabilizing the black start units. Supply to other customers within the sub-system can be provided after adequate generation is available within the subsystem.

c) Synchronization of the sub-system

After each sub-system is reenergized, the last step in the restoration procedure is to resynchronize these sub-systems.

1.3. General Guidelines

1. A subsystem should

- Contain at least one unit with black start capability.
- Be able to supply startup power to non-self starting units within subsystem.
- Be able to supply essential loads within subsystem.

2. Strict active power balance is to be maintained while building up the subsystem. Voltages in the subsystem are to be closely monitored and all available reactive resources are to be judiciously used for maintaining the voltages within permissible range.

3. Simultaneous, immediate and independent measures should be taken to supply station service for the hot start of the boilers before elapse of the allowable time interval between shutdown and hot restart. This interval is usually of the order of **half an hour or less**.

4. Interconnection of generating stations within each sub-system should be done as soon as possible. Such an interconnection should be carried out after generating units attain the minimum specified generation, but prior to restoration of full load within the sub-system.

5. Switching in and switching out of load in the subsystem should be done in small quantum to avoid excessive frequency deviation. The general guide is to pick up load when the system frequency is high and increase generation when system frequency is low. Restore smaller and radial loads prior to larger and low voltage AC network load, while maintaining a reasonably constant real to reactive power ratio.

6. Maintaining steady state stability by having loads in vicinity of each station supply is important.

7. Maintain system voltage within plus and minus 5% by maintaining generator voltages at low end of range during early stages of restoration and adjusting transformer taps to appropriate positions. In case of hydro stations it is desirable to operate more number of units at 0-10 % loading so that dynamic reactive reserves are available.

8. Energizing only one circuit of the double circuit transmission lines, and operating generators under excited (i.e. in the leading mode) to the extent that stability considerations allow is recommended during the early stages of restoration from voltage considerations. However redundancies in the network should be built up as soon as possible by way of restoring parallel circuits between two points.

9. While energizing a system from 220 kV voltage side, bring the transformer tap position to its nominal or towards lower turns ratio. (i.e. between 9 & 17 in a typical 1 to 17 tap transformer.)

1.4. Priorities during system restoration

1. Extending power for synchronizing islanded nuclear power stations or startup power to nuclear power plants.
2. Extending start-up power to thermal power plants.
3. Extending start-up power to non-self starting hydro power plants.
4. Restoration of traction power supply.
5. Building up subsystem and synchronizing with each other.
6. Restoration of supply to other essential loads such as Hospitals etc.
7. Restoration of supply to all other customers.

- This document covers Sl. no. 1 to 4 above. It is expected that at state level, each SLDC /distribution company would have a similar procedure for restoration of essential consumer load with in the state.
- At the same time due priority shall also be given to restore power supply to communication system nodes and repeater stations.

1.5. Line Charging Guidelines during Restoration

1. Ensure that line to be charged is free from fault. i.e. faulted line shall not be charged (or used in the restoration procedure).

2. Before charging, ensure that communication is available between both ends and protections are in service and no protection is by-passed.

3. During restoration, lines of lower voltage levels should be given first priority.

4. The line should be charged from the end with higher fault level in order to limit the over voltage at charging end.
5. In case one bus is completely dead, charge the line from the other end, which is live and close the breaker at the dead bus end. Before closing all other breakers should be opened at the dead bus end.

   However, the bus/line reactors may be kept in service (as per requirement) with breaker/isolator in closed position before charging the dead bus.

6. If two buses have almost same short circuit level (3-ph) and neither is a generation station, charge the line from the bus with lower voltage. At the charging end, all measures should be taken to control high voltage

   a. Bus reactors may be taken in to service
   b. Generators at the charging end may be operated at reduced voltage (less than 1 pu.) and in leading power factor mode
   c. Suitable measures may be taken to avoid large frequency variations
   d. Loads may be taken into service in small steps

7. At the synchronizing end, control of standing phase angle (SPA) to less than or equal to 20^{o} would help in minimizing jerk or sudden rush of power. For reduction of SPA, the following measures need to be taken up.

   a. Reduce generation at those generators that are sensitive to the SPA.
   b. Shed loads at selected buses.
   c. Simultaneous backing down of generation and shedding of load.
   d. Increase of generation at the sensitive buses.

   The recommended practice for synchronizing lines is always through check synchronization relay that normally is set for 35^{o} (above which breaker closing is not permitted). For most of the lines, SPA < 35^{o} would suffice. However, in case of lines inter connecting two major generating stations; it is prudent to limit the SPA to around 20^{o}.

8. Open-end voltage should not exceed the voltage level at which over-voltage protection operates (generally 110%) of nominal voltage. Reducing the voltage at the charging end could control the open-end voltage. The end with lower voltage would be ideal for charging as this minimizes the rise of voltage at the open end.

9. If the open-end voltage is too high, line charging VARs would increase and it may be difficult for the charging end to sustain the

voltage increase. Ensure adequate voltage control measures at the charging end to contain high open-end voltage. Keep the charging end voltage as low as possible. If required transformers at the charging end may be used as bus reactors by keeping it energized while line charging.

10. While back charging long 400kV lines, the problem of Ferro-resonance may occur. Hence, adequate measures such as taking bus/tertiary reactors in to service and most importantly some load on the transformer shall be taken.

11. When one end is generating station end.

    While charging a line from generating stations during restoration, care should be taken to ensure that sufficient generation is available and/or connections with other stations at the charging end to absorb the (leading VARs) reactive power without difficulty. Before charging, ensure by addition of load preferably or through excitation control, that these generators are operating in such a manner that sufficient margin are available for absorbing line charging MVAR. Also ensure that, the generator EHV bus voltages are kept low around 0.9 per unit or even less by excitation control to ensure less open-end voltage rise.

    In case of hydro stations, it is suggested that 2-3 units may be kept running to have larger dynamic reactive reserves to facilitate (220-400 kV) line charging.

12. One end Line Reactor Available

    In case, line reactor is available at only one end, it is preferable to charge the line from the end without reactor and synchronize at the end with reactor.

    If the line is to be opened, open from the end where line reactor is available.

    Thumb rule is "synchronize or open from the end where line reactor is available".

1.6. Guidelines for over voltage control during Restoration

1. Taking into account the equipment voltage limitations and fault contingency, it is recommended that no line shall be energized if by doing so, the voltage at the remote end would rise to more than 1.2 pu. Of normal or 1.1 x (transformer tap or circuit breaker rated maximum voltage), whichever is lower?

2. Sustained over voltages can be controlled by absorbing the large charging reactive power of the lightly loaded transmission lines.

This can be accomplished by:

1 Having sufficient under excitation capability on the generators,

2 Connecting reactive loads (lagging power factors) to the underlying system including shunt reactors,

3 Removing all sources of reactive power and switching off shunt capacitors,

4 Operating parallel transformers on different taps to increase circulating currents and reactive power losses,

5 Energizing only those transmission lines which carry significant load and avoiding the energization of extra lines which will generate unwanted reactive power, and

6 Maintain a low voltage profile on the transmission line, since the charging currents are proportional to the square of the voltage.

3. The extent of the generation voltage reduction is usually constrained by under excitation of generators by a number of limiting factors, including generator terminal low voltage limit (as limited by power plant auxiliary equipment), reactive ampere limit relay, minimum excitation limit relay, and rotor core and heating limit.

4. Switching transients are not usually the limiting factors in reenergizing a system. Generally, if the steady state voltages are less than 1.2 per unit of their nominal values, the switching transients can be managed by typical arrestors with ease. Based on the experience of mock blackstart exercises of charging long lines from generating stations, it is recommended that whenever charging a long line in the weekly connected system, a delay of 100 ms shall be introduced (only during charging) in the Overvoltage stage-II (at 150 % over-voltage) protection which is otherwise instantaneous. A notable exception is energizing transformer-terminated lines, which may result in harmonic resonance and damaging over voltages.

5. Control of Harmonic resonance:

a) Sustained harmonic over voltages caused by over excitation of transformers, can be controlled by selecting a transformer tap which equals or exceeds the power frequency voltage applied (or lowering system voltage to at or below the tap) before energizing.

b) Harmonic resonance can be damped by connecting sufficient underlying loads at the sending end of a line, or by connecting dead load on the transformer to be energized.

c) High source impedance can be reduced by starting more generators and connecting underlying loads.

d) The reactive power of a lightly loaded system can be reduced by minimizing the number of unloaded lines to be energized and setting the sending-end transformers at the lowest tap position.

1.7. Emergency operating instructions for operation of Power Stations under emergency situations including islanded operation

These instructions are for situations when an island has been formed randomly and not by design. (Say, part of under frequency islanding scheme.)

1. In case of any disturbance in the system, SLDC/NRLDC would identify whether any power station has survived or not.

2. In case power plant has survived SLDC/NRLDC would identify the island formed, if any, and determine its size (in MW). All the power stations and substations forming part of this island would be informed accordingly.

3. SLDCs would advise the substations forming part of the island not to connect/disconnect any load (including any scheduled rostering) unless instructed by the SLDC or Power Station. These substations would be on a high alert.

4. In case any power plant output within the island is expected to decrease due to problem with any auxiliary, it would immediately send an SOS to the adjacent substation for shedding the quantum of load. All telephone numbers required for the purpose should be available with the power station operating personnel.

5. In case the substation load is expected to go up normally as per its load profile, load shedding in small steps would be done in advance so that the frequency is maintained close to 50.5 Hz.

6. In case of frequency remaining above 51 Hz, the power station(s) in the island would control the same and maintain it around 50.5Hz.

7. **Simultaneously** SLDC would identify the point of synchronization in co-ordination with NRLDC and take steps to synchronize the subsystem with the main grid. In case the power stations in the

island has many feeders out of which some has tripped, it might be preferable to extend the grid supply to the power station on these feeders so as to facilitate quick synchronization of supply at the power station itself.

1.8. General precautions to be followed during synchronization of a sub-system with another sub-system:

a) A strict load-generation balance shall have to be maintained while developing the subsystem.

b) Due to start up of the areas separately, the related supplies are to be synchronized at the earliest opportunity and a combined subsystem is to be formed at the earliest for strengthening the subsystem.

c) The railway traction load at the various points and start up supplies to generating stations is to be extended on top priority.

d) The voltages at different nodes / buses are to be maintained within normal range by the use of bus / line reactors and by operating the units in synchronous condenser mode wherever applicable for absorbing /generating VARs.

e) In respect of large hydro power stations connected on 400 kV system, after self-starting of the hydro units and before charging a 400 kV line from the power station end, the bus reactor(s) at the remote end should be taken in service and keep the breaker of the line closed at the remote end. This will ensure that as soon as the line is charged from the power station end both the line reactor (if any) and bus reactor will come into service at the remote end.

1.9. Provision for Recovery Procedure in IEGC:

According to IEGC Para 5.8(d) "*The RLDC is authorized during the restoration Process following a blackout, to operate with reduced security standards for voltage and frequency as necessary in order to achieve the fastest possible recovery of the grid*."

Chapter-2: Overview of NR System Restoration Procedure

2.1. Introduction to Northern Region Electricity Grid

Northern Region electricity grid is the largest region amongst the five regions of the country in terms of geographical area as well as the number of constituents. The total effective installed capacity in the region, as on 31st Dec 2011 is 49961 MW with a peak demand of the order of 38000 MW.

As per the geographical structure of the region, the major generating sources are located either in the South-Eastern part of the region consisting of Super Thermal Power Stations at Singrauli, Rihand and Anpara or in North-Western part of the region consisting of hydro generating stations of BBMB, SJVN, THDC, NHPC, KWHEP & ADHPL & BASPA HEP.

Due to the location of the major generating sources at the extreme ends and load centers in the central part of the region, consisting of Delhi, Haryana, Punjab, Western U.P. and Northern Rajasthan, a large quantum of power flows through the long lengths thereby sometimes resulting in high loading of transmission network with large voltage gradients.

Further, due to a large gap in demand and availability during the peak hours as well as sudden change in weather conditions, at times the system parameters undergo wide variations and threaten grid security. All these factors coupled with the equipment failure/faults/mal-operation lead to system contingencies.

During winter season, fog engulfs the whole Northern region which causes transient faults in transmission lines leading to system contingencies.

2.2. Northern Region System Restoration

Since the Northern Region consists of a large network, in the event of a total black out, extending start-up power from one end of region to the other end is rather impractical, and the restoration has to be achieved in a sectionalized manner.

Therefore, based on the geographical boundaries and for ease and speedy restoration, at the time of black-start the Northern Region is considered to have been divided into four different “subsystems”.

So that in the event of total grid failure, initially each subsystem is to be restored independently as per details given for each subsystem in the following chapters. List of Northern Region Sub-System is given at Table1-1

Table 1-1 Northern Region Sub-Systems

Sl. No.	Subsystem Name
1	Eastern U. P. Subsystem
2	North-Central Subsystem
3	Rajasthan Sub-System
4	Western U. P. / Uttarakhand Subsystem

Once the sub-systems are separately built-up, these can be synchronized in stages to integrate into the complete system. For the purpose of quick understanding and ease of restoration, each chapter has been further subdivided into following sub-sections:

- Sub-system Overview.
- Sub-system Restoration Procedure.
- Sub-system Synchronization.
- Restoration Stages and Start-up Sequence in a Sub-system.

By following the steps as detailed in the above sub-sections, each of the subsystems can be restored independently and t hereafter the complete system can be integrated in the fastest possible manner.

Exhibit-2A and E xhibit-2B explains the boundaries and the synchronizing sequence of different subsystems respectively. These boundaries have however, been defined on the criteria of most likely scenario. During the actual operation there can be v ariations in the above boundaries and / or sequence, depending upon the real time situations and other factors, for which NRLDC shall carry out the overall co-ordination.

Therefore, in the event of a di sturbance all the constituents should remain in contact with NRLDC for instant exchange of the information, and for carrying out coordinated efforts.

2.3. Restoration of Power Supply to Nuclear Stations

In order to meet the “Safety norms of the Nuclear Stations" it is essential that power supply to the Nuclear Stations be r estored on priority basis. Nuclear Power Plants in the region are as listed below.

1) Narora Atomic Power Plant - 2 x 220 MW,
2) Rajasthan Atomic Power Station (A)-1 x 100 MW, 1x 200 MW
3) Rajasthan Atomic Power Station (B)-2 x 220 MW.
4) Rajasthan Atomic Power Station (C)-2 x 220 MW

The description of the restoration of different subsystem contained in different chapter of this document also contains the steps to be taken to for speedy restoration of power supply to the nuclear stations.

2.4. Restoration of power supply to Railway Traction

In the event of system black out, the power supply to Railway Traction has to be restored on top most priority. Chapter-7 of this document explains the detailed steps to be taken for early restoration of power supply for Railway Traction.

2.5. Start-Up Power from Western Region

Since major Super Thermal Power Stations in the region, namely; Singrauli (2000 MW), Rihand (2000 MW), Anpara (1630 MW), Anpara-C (1200 MW) and Obra (1442 MW), having a total installed capacity of 8272 MW are located in the extreme South - Eastern part of the region, it is very essential that for fast normalization of the system the start-up power to these stations be extended at the earliest opportunity.

Initially the start-up power to these stations was extended from the Rihand hydro station of U.P. or on 132 kV ckt. from Vindhyachal (WR) to Singrauli and Rihand. It has however, been observed that both these sources are “weak” and not very much reliable.

Therefore, since February 1997, a provision has been made to avail start-up power from Western Region on 400 k V Vindhyachal AC bypass link. This link was successfully utilized to extend start-up power to Northern Region during the collapse of Eastern U.P. Subsystem on 01.08.1999 and 22.09.1999 as well as during the failure of the complete Northern Regional Grid on 02.01.2001 and its operation has found to be satisfactory. Chapter-8 of this document explains the set-up of 400 kV Vindhyachal A.C. by pass link and t he steps for its operation.

After the establishment of 400 kV Vindhyachal A.C bypass link, the 132 kV ckt. from Vindhyachal to Singrauli / Rihand, as mentioned above can be used as a s upplementary link. Similarly the 132 kV circuit between Singrauli and Rihand (Hydro) which has been looped-in / looped-out at Renusagar Thermal Station of Hindalco can also be used to supplement the start up functions by availing the supply from Renusagar as per the agreed arrangement.

2.6. Start-Up Power from Eastern Region

Since December 2008, the Sasaram HVDC Back -to -Back station has been bypassed through an AC bypass link. It is also tested on the HVDC BTB as and when required. Chapter-9 of this document explains the set-up of Sasaram 400 kV A.C. Radial Mode operation, and the steps involved in availing black-start Power.

2.7. Load Generation Balance and Spinning Reserve

While restoring the system, besides maintaining load generation balance, sufficient operative spinning reserve is to be k ept in each subsystem. All efforts need to be carried out by all the constituents to maintain the parameters within the subsystem, near nominal values for security of operation of the restored subsystem as well as for ease of synchronization.

In order to provide a valuable guidance to maintain a balance between load and generation, the estimate of the immediate support/generation likely to be available in each sub-system vis-à-vis the essential load to be met during the system restoration has been explained in each of the chapter under sub-section 'Subsystem Overview'. All the constituents must endeavor to maintain a l oad generation balance in their respective areas in line with the details given in this document.

At the same time, it is extremely important that the different generating units are operated with free governor mode so as to take small variations. In order to control the system parameters and catering any other eventualities a close monitoring and check is to be maintained on the different loads, which are energized in the different islands formed after a disturbance in any subsystem. During system restoration, the following loads are to be met on priority basis:

- Survival power or startup power to nuclear power plants.
- Startup power to thermal power plants.
- Startup power to non-self starting hydro power plants.
- Traction power supply
- Supply to other essential loads such as Hospitals etc.
- Supply to all other customers.

Therefore, while reviving the system, due importance must be given to all above loads. In the document at various places different priorities have been shown for the purpose of redundancy and reliability in achieving the target. In order to achieve this objective, at all such places simultaneous action should be initiated and/or prepared and kept in readiness, so that in the event of difficulties in achieving the target through first priority, it may be achieved through the subsequent ones without much loss of time.

2.8. Black Start of Gas Stations

NTPC / NCR in formed that all Gas Turbines in NCR Re gion have capabilities of Black Starting in the event of Grid failure/total blackout. Gas turbines can continue to operate on House-load/ be started and kept on house load operation. Units can be synchronized immediately on getting juice from grid. This will help in speedy stabilization of grid network.

As regards charging of lines and associated transformers, gas turbines have limitation on block load, while charging dead grid. Machines are run in speed load mode and there are limitations of ramp loading in Gas Turbines.

2.9. Voltage Control during build-up of system

Following a blackout, quick restoration of the network is a basic requirement. This is often constrained by the high voltage levels during restoration. In order to ensure that the voltage levels remain at a satisfactory level, the following steps may be taken:

1. Selected generating units may be operated in under-excited mode at low power levels say less than 5% of full load. This would provide sufficient reactive sinks while building up of the system. In the build-up of the Northern Region some of the generating stations where at least one unit can be operated in such a manner are Rihand (Hy), Obra (Hy, Chibro, Khodri, Ramganga, Bhakra (L), Bhakra (R), Jhakri, Baspa, Bairasiul, Chamera I & II, Salal, RSD, Pong, R.P.Sagar, J.Sagar, Dulhasti, AD hydro and Baglihar.

2. In order to avoid tripping of 220/132 kV, 220/66 kV and 220/33 kV transformers on over-fluxing, the Tap Changer may be used to control this situation by going to the minimum tap position (i.e. more number of turns).

3. While extending the network, a small load may be switched in at the substations before charging any line further.

4. While charging 400 kV lines, reactors (Line/Bus/Tertiary) shall be used to control the over voltages.

5. Various reactive power control methods and its impact on the Power system are given at annex-II. Ready reckoner for reactive power management is given at annex-IV.

2.10. Monitoring of air pressure at substations

Under a blackout situation, a restoration is often delayed due to the circuit breakers (CBs) getting locked out on account of low air pressure after the air compressors trip. This is due to air leakages in the system. Wherever DG sets are provided in the substation, air compressors could be started immediately and the air pressure are maintained. In order to cut down delays in restoration of the system in the event of contingencies, the leakages in the compressed air system should be monitored and checked on a regular basis as a routine check. Furthermore, DG sets, if so far not available, may be provided by the utilities at the substations, at least at all the 400 kV substations and the 220 kV substations falling in the trunk route in the system restoration procedure.

2.11. SCADA system during blackout

It is often observed that following a blackout a large number of real time data in the SCADA system become 'suspect'. It is mostly caused by failure of auxiliary supply (48 volt DC) to RTUs and communication system (PLCC, Micro Wave /Fiber optic etc.). Due priority may be given to ensure availability of telemetry at control centers. System restoration becomes much faster with the availability of accurate digital status and analog data.

Stable communication system and proper auxiliary power supply at RTU locations and communication system nodes are essential for functioning of SCADA system. The concerned departments looking after these systems shall be alerted to take corrective actions in case of any telemetry failure. Many a times forced polling at RTU locations quickly reestablishes the link between RTU and control center in case of a transient fault in the link.

2.12. Mock trials

The restoration procedure would be used only in case of a disturbance / blackout. It is important that when there is an actual disturbance all the players play their respective roles without any problem. As a confidence building exercise as well as to ensure success in the event of contingencies, mock trials of certain steps in the restoration procedure, wherever feasible, need to be done regularly, at least once in six months. It is suggested that these trials be done at least for the following locations, which would basically involve start-up of a unit, and / or extension of supply to the adjacent substation as mentioned in this procedure. Splitting of buses at substations, wherever possible may also be done to facilitate mock trial.

a) Hydro Plants

1. Rihand (Hy) Hydro Plant
2. Bhakra Hydro Plant
3. Bairasiul Hydro Plant
4. Salal Hydro Plant
5. Chamera-I Hydro Plant
6. Chamera-II Hydro Plant
7. Uri Hydro Plant
8. Nathpa Jhakri Hydro Plant
9. Baspa Hydro Plant
10. Chibro Hydro Plant
11. Khodri Hydro Plant
12. Ramganga Hydro Plant
13. Rana Pratap Sagar Hydro Plant
14. Jawahar Sagar Hydro Plant
15. Vishnu Prayag
16. Tehri

17. Dhauli Ganga
18. AD HPP
19. Dulhasti
20. Baglihar
21. Karcham Wangtoo
22. Koteshwar

b) Thermal Plants

1. Renusagar Thermal Plant
2. Faridabad (Gas Plant
3. Auraiya (Gas) Plant
4. Dadri (Gas Plant
5. Delhi GTs Plant
6. Pragati Gas Plant

7. AC Bypass

1. At Vindhyachal HVDC back-to-back
2. At Pusauli HVDC back-to-back

2.13. Synchronous Operation of "N-E-W"Grid

Northern Region was synchronized with Central Grid (i.e. NER+ER+WR) at 1220 hrs of 26th August 2006 through 400 kV Muzaffarpur- Gorakhpur D/C and 'N-E-W' grid was formed. Since the formation of "NEW" grid the capacity of interregional tie line between Northern grid and C entral grid was further strengthened by commissioning of following 400 kV links.

Sl. No.	Tie line Name	Link between
1	400 kV Agra-Gwalior-I	NR-WR
2	400 kV Balia Patna D/C	NR-ER
3	400 kV Biharsharif Balia II	NR-ER
4	400 kV Barh-Balia-I	NR-ER
5	400 kV Barh-Balia-II	NR-ER
6	400 kV Biharsharif Balia I	NR-ER
7	400 kV Agra-Gwalior-II	NR-WR
8	400kV Kankroli-Zerda	NR-WR
9	400 kV Zerda - Bhinmal	NR-WR

Immediately after commissioning of 400 kV Agra-Gwalior the 220 kV Auraiya Malanpur and 220 kV Auraiya Mahegaon circuits between NR and WR were also connected in closed loop in April 2007.

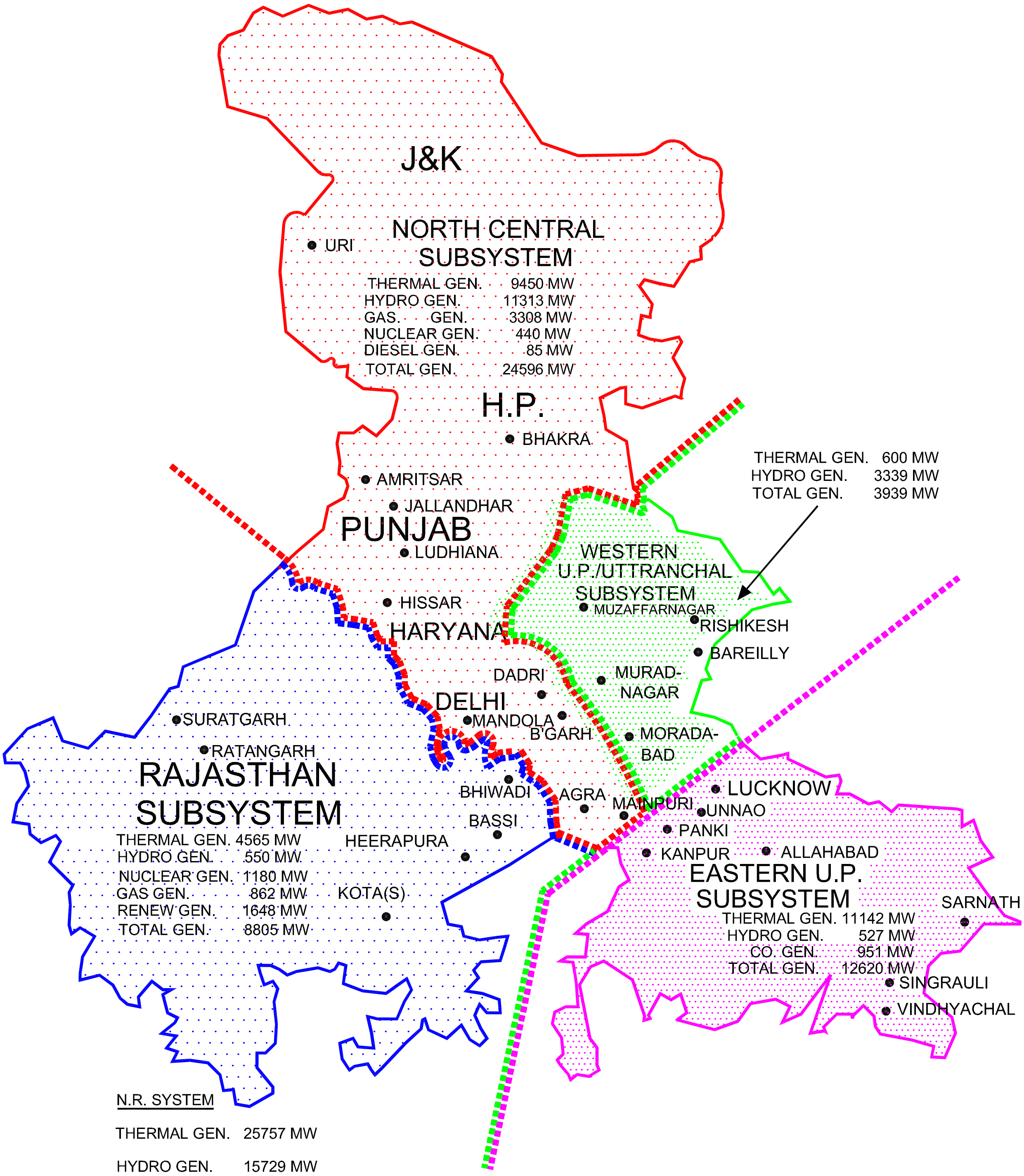
In the meantime trial run of bypassing the Sasaram HVDC Back to back started from 1st Dec 2008. The 220 kV Sahupuri Sasaram link , that was operating in radial mode between NR and ER , was also connected in closed loop after bypassing the Sasaram back to back link on 1st Dec 2008.

The long desired synchronization of dormant 220 kV Morak – Badod and 220 kV Kota- Badod link between NR and WR were also done on 24th Jan 2008 after intervention of CERC and i nitiative taken by NRLDC along with the support of all other agencies involved.

With all these tie lines at 400 kV and 220 kV level, the interconnection of Northern Region with Central grid has become strong. Now, availability of startup power from neighboring region in case of contingencies is much more reliable. However the region should be planned to be self sufficient in terms of black start facilities.

EXHIBIT-2A

NORTHERN REGIONAL GRID : MAJOR SUBSYSTEM



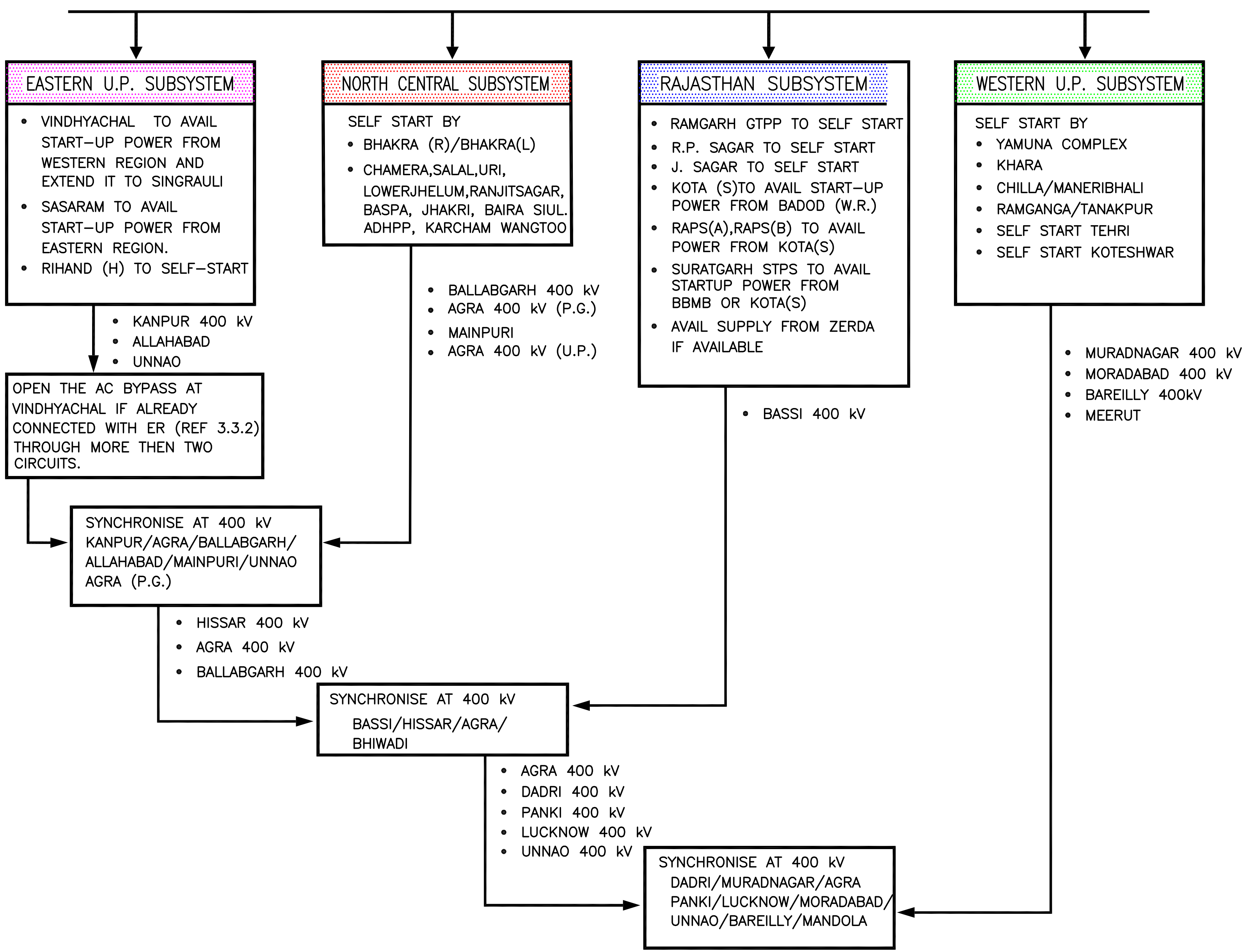
N.R. SYSTEM

THERMAL GEN.	25757 MW
HYDRO GEN.	15729 MW
GAS GEN.	4170 MW
NUCLEAR GEN.	1620 MW
RENEW GEN.	1648 MW
CO GEN.	951 MW
DIESEL GEN.	85 MW
TOTAL GEN.	49960 MW

	NRLDC/POWERGRID	
	NORTHERN REGIONAL GRID:MAJOR SUBSYSTEM	
SCALE:NOT TO SCALE	DRN. BY Ramjit	JANUARY, 2012

EXHIBIT – 2B

NORTHERN REGIONAL GRID : SUBSYSTEM SYNCHRONISATION



DRN.BY Ramjit | JANUARY, 2012

Chapter-3: Restoration of Eastern U.P. Subsystem

3.1. Subsystem Overview

Eastern UP sub-system is connected with Western U.P. / Uttarakhand Subsystem and North-Central (NC) Subsystem within region. It is also connected with eastern region and w estern Region. Detailed description of this sub-system restoration is given in this chapter.

3.1.1. Important Connecting Links with other Subsystems:

a) With Western U.P./ Uttarakhand Subsystem:
1. 400 kV Lucknow(UP)-Bareilly (PG) S/C
2. 400 kV Lucknow(PG)-Bareilly (PG) D/C
3. 400 kV Unnao Bareilly (UP) D/C
4. 400 kV Panki - Muradnagar S/C
5. 220kV Shahjahanpur-Bareilley
6. 220kV Rosa – Badaun D/C

b) With North-Central (NC) Subsystem:
1. + 500 kV Rihand - Dadri HVDC Bipole
2. 400 kV Kanpur-Ballabgarh I, II & III
3. 400 kV Kanpur-Agra (PG) S/C
4. 400 kV Unnao-Agra (UPPCL) S/C
5. 400 kV Allahabad Mainpuri D/C
6. 400 kV Kanpur- Auraiya D/C
7. 220kV Kanpur-Mainpuri
8. 220kV Panki-Chibramau-Mainpuri

c) With Eastern Region
1. 400 kV Muzaffarpur-Gorakhpur D/C
2. 400 kV Patna – Balia D/C
3. 400 kV Biharsharif-Balia D/C
4. 400 kV Sasaram-Sarnath
5. 400 kV Sarnath-Allahabad
6. 400 kV Barh-Balia D/C
7. 220 kV Sasaram-Sahupuri
8. 132 kV Karmnasa-Chandil-Sahupuri
9. 132 kV Karmnasa-Sahupuri

d) With Western Region
1. Vindhyachal HVDC Back to Back
2. 132 kV Morwa-Bina-Anpara
3. 132 kV Morwa-Anpara
4. 132 kV Vindhyachal-Singrauli
5. 132 kV Vindhyachal-Pipri(Rihand-Hy)

3.1.2. Major Generating Stations:

a) Thermal: Singrauli (STPS), Rihand (STPS), Anpara, Obra (Th), Renusagar, Unchahar, Tanda, Panki , Paricha and Rosa.
b) Hydro: Rihand (Hy), Obra (Hy)
c) Gas: Nil
d) Nuclear: Nil

3.1.3. Sources of Start - up Power:

a)	From WR - on 400 kV Vindhyachal AC By-Pass link	:100 MW
b)	From ER - on 400 kV Pusauli AC By-Pass link	:100 MW
c)	From ER - on 220 kV Sasaram-Sahupuri link	: 50 MW
d)	Rihand (Hy) - Self start	:150 MW
e)	Obra (Hy) -Start-up from Rihand (Hy)	: 50 MW
	Total:	**: 450 MW**

Note: In the initial run-up very nominal quantum (only 100 MW) of assistance has been kept from WR and ER so that such a support is instantaneously available without any affect on the parameters/health of the other region. However, depending upon the actual scenario, this quantum may be higher and even go up to the level of 300-400 MW.

3.1.4. Requirement of Start-up Power:

The approximate estimation of the start-up power requirement in the initial stages at various plants / loads are as below, corresponding to the availability mentioned at 3.1.3 above:

a)	Start up power at Singrauli (STPS)	: 70 MW
b)	Start up power at Rihand (STPS)	: 100 MW
c)	Start up power at Anpara	: 70 MW
d)	Start up power at Anpara-C	: 40 MW
d)	Start up power at Unchahar	: 40 MW
e)	Start up power at Obra (Th)	: 40 MW
f)	Start up power at Tanda	: 20 MW
g)	Start up power at Panki	: 20 MW
h)	Start up power at Renusagar	: 10 MW
i)	Start up power at Rosa	: 20 MW
i)	Railway Traction and other essential Load	: 80 MW
	TOTAL:	**510 MW**

3.1.5. System Synchronization:

After subsystems build - up and stabilization, the Eastern U.P. Subsystem can be synchronized with North-Central (NC) Subsystem & Western U.P. / Uttarakhand Subsystem at the following possible connections:

a) With North-Central (NC) Subsystem:

i) On 400 kV Kanpur - Agra circuit at Kanpur / Agra,
Or alternatively;
ii) On 400 kV Kanpur–Ballabgarh at Kanpur / Ballabgarh
Or alternatively;
iii) On 400 kV Allahabad-Mainpuri at Allahabad /Mainpuri.
Or alternatively;
iv) On 400 kV Unnao Agra at Unnao or Agra (UP).
Or alternatively;
v) On 400 kV Kanpur-Auraiya at Kanpur or Auraiya.

b) With Western-U.P / Uttarakhand sub-system:
i) On 400 kV Panki – Muradnagar at Panki / Muradnagar
Or alternatively;
ii) On 400 kV Lucknow(PG)-Bareilly (PG) at Lucknow (PG) / Bareilly (PG)
Or alternatively
iii) On 400 kV Lucknow (UP)-Bareilly (PG) at Lucknow (UP) / Bareilly (PG)
Or alternatively
iv) On 400 kV Unnao - Bareilly at Unnao / Bareilly.

Caution: Before synchronization with other subsystems, the action in regard to disconnection of Eastern U.P. Subsystem from WR / ER be taken as described under Para 3.3.2.

3.2. Subsystem Restoration Procedure

i) In order to build-up the Eastern UP subsystem, the following avenues are available as start-up power:

a) From WR through 400 kV Vindhyachal AC By-pass link
b) From ER through 400 kV Sasaram AC By-pass link
c) From Renusagar station of Hindalco
d) Self start by Rihand (Hy) and Obra (Hy)
e) From WR through 132 kV Vindhyachal-Singrauli line
f) From ER through 220 kV Sasaram-Sahupuri line.

ii) The Eastern U.P. Subsystem shall be built-up primarily by availing start-up power from Western Region on Vindhyachal A.C. By-pass Link, from Eastern Region on Sasaram A.C. By-pass Link and 220 kV Sasaram-Sahupuri line to be supplemented by the self-start of hydro units at Rihand hydro and / or by availing possible support from the generation at Renusagar.

Note: Specific details regarding operation of 400 kV Vindhyachal A.C. By-pass Link and 400 kV Pusauli A. C. By-pass Link are given at Chapter –8 & 9 respectively.

At the time of subsystem built-up, the actions to be taken at the major generating stations / grid sub-stations in the Eastern U.P. Subsystem are as described below.

3.2.1. Vindhyachal HVDC (Back to Back Station)

i) In the event of total loss of power supply at Vindhyachal (North) 400 kV Bus, the station would immediately contact NRLDC and 400 kV Singrauli Sub-station to ascertain the status of power supply. In case of total loss of supply in Eastern U.P., Vindhyachal shall initiate action for extension of Western Region (WR) supply to Singrauli. Vindhyachal shall finally extend the supply to Singrauli after confirming the readiness from Singrauli end. (The specific operations to be carried out at Vindhyachal are given under Chapter -8).

ii) In the event of any difficulty/problem in availing the power from WR on 400 kV Vindhyachal AC By-pass Link, due to any unforeseen problem, the matter shall immediately be brought to the notice of Singrauli and NRLDC.

Note: Even though, NRLDC Control Room and Vindhyachal HVDC station shall endeavor to confirm the actions to be taken in the event of total black-out in the Eastern U.P., extension of WR power from Vindhyachal to Singrauli shall be carried out without waiting for any code from NRLDC / CPCC, NR-1 Singrauli, except that just before extending the supply, Vindhyachal shall interact with Singrauli and obtain its readiness for the same.

3.2.2. Singrauli (STPS)

Singrauli (STPS) shall avail start-up power from Western Region through 400 kV Vindhyachal AC By-pass Link and put it to immediate utilization for lighting up of the units at the station. [For the specific number of units to be lighted up please also refer Para 3.2.22 (iii)]. Simultaneously, the persons at Singrauli shall also take up the following actions:

i) Start-up power shall be extended by Singrauli (STPS) to Rihand (STPS) by charging 400 kV Singrauli-Rihand D/C from Singrauli end.

ii) Start-up power shall be extended by Singrauli to Anpara (Th) by charging 400 kV Singrauli-Anpara S/C line from Singrauli end.

Note: In view of maintaining air pressure in ABCB, Singrauli end breakers of Rihand (STPS) and Anpara (Th) lines may remain closed and power is extended as bus is charged.

iii) Singrauli shall extend power to Renusagar /Rihand (Hy) on 132 kV Singrauli-Renusagar-Rihand (Hy) line in order to extend the start-up power/ synchronization of two supplies in consultation with

Renusagar/Rihand (Hy).

iv) Singrauli shall also extend supply to 400 kV Kanpur by charging 400 kV Singrauli-Kanpur or one circuit of 400 kV Singrauli-Allahabad line. While charging 400 kV Singrauli-Allahabad circuit, the bus reactor at Vindhyachal shall be suitably used so as to maintain the bus voltage at Singrauli end to a value around 1.0 pu.

Caution:

i) In the scenario of non-availability of start-up power from WR through Vindhyachal AC bypass link Singrauli shall avail start-up power in following descending order of priority; (i) from Renusagar (ii) from Rihand (Hy) and (iii) from WR on 132 kV Vindhyachal-Singrauli line.

ii) 132 kV Singrauli-Renusagar-Rihand (Hy) circuit is always to be kept in charged condition from Rihand (Hy) end. ***(The Rihand (Hy) end breaker of 132 kV Singrauli-Renusagar-Rihand (Hy) circuit is presently out of service. Till the time, breaker at Rihand (Hy) end is brought back in service, the 132 kV Singrauli-Renusagar-Rihand (Hy) circuit shall be kept charge from Singrauli end. UPPCL/ UPJVUNL shall however expedite to bring back the Rihand (Hy) end breaker, in service, at the earliest.)*** In the event of a black out, Rihand (Hydro) may self start the units and extend the supply up to Renusagar. (For extending start-up power in the event of collapse of all the units at Renusagar or for synchronization, in the event of survival of Renusagar) Alternatively in the event of any delay / failure in self start of units at Rihand (Hy) the extended supply from Renusagar/ Singrauli can be used by Rihand (Hy) as start-up power.

iii) Extension of power from Singrauli (STPS) to Rihand (STPS) and Anpara on 400 kV circuits shall be carried out without waiting for any code from NRLDC, except that just before charging the line Singrauli shall confirm from the other ends about their readiness. However, extension of supply to/from Renusagar/Rihand (Hy) at 132 kV level shall be depending on the conditions in real time and based on the status of Renusagar stated under Para 3.2.2.2.b.

3.2.3 Rihand (Hy) or (Pipri)

i) Self-start the units at Rihand (Hy) and extend the power up to Renusagar/Singrauli on 132 kV Rihand (Hy) –Renusagar-Singrauli S/C, in order to synchronize the Rihand (Hy) supply with Renusagar/Singrauli supply. However, in the event of non-survival of Renusagar, the extended supply from Rihand (Hy) can be used by Renusagar for start-up of its units.

ii) In the event of failure of Rihand (Hy) to self-start, avail start-up power from Renusagar/Singrauli on 132 kV Singrauli-Renusagar-Rihand (Hydro) S/C and start units.

iii) Extend power to Obra (Hy) for synchronization / start-up of the units at Obra (Hy).

iv) Extend start-up power to Anpara (Th) through 132 kV Rihand (Hy) - Anpara line.

Caution:

i) For fast build - up of the sub-system in Eastern UP area and to regulate the system parameters, the early start-up of the units at Rihand (Hy) is extremely essential and the same is to be closely monitored and coordinated by SLDC, Lucknow. Furthermore, in order to stabilize the units at Rihand (Hy), these must be synchronized with the supply extended from Renusagar / Singrauli at the earliest opportunity.

ii) In the event that the units at Rihand (Hy) have been self started and the supply from Renusagar / Singrauli has not been extended due to any unforeseen reasons, the Rihand (Hy) should take necessary steps for building up of the system viz. extending the supply to Obra (Hy), Anpara and a close watch and control over the parameter is to be maintained.

3.2.4 Renusagar

Under normal conditions the connections of Renusagar with Rihand (Hydro) / Singrauli is as given in annexure –3C.

Case (a): Renusagar islands and survives:

In case of survival of Renusagar, Renusagar shall take following actions.

i) Renusagar shall extend the supply to Rihand (Hy) in order to extend startup power/ reference to Rihand (H) units for starting-up or for synchronization. After the power is extended from Renusagar up to Rihand (Hy), the synchronization at Rihand (Hy) bus would be the responsibility of Rihand (Hy) and would be carried out by the station by varying its own generations as well as at Renusagar by coordinating with it.

ii) In case the units at Rihand (H) self-start before the start-up power reference is extended from Renusagar, then Rihand (H) shall extend reference towards Renusagar and the extended supply / reference from Rihand (Hy) would be synchronized by Renusagar with its own supply by varying its own generation as well as that at Rihand (H) by coordinating with it.

iii) In case there is some delay in getting the WR supply from Vindhyachal at Singrauli and Singrauli station wants start-up power from Renusagar / Rihand (Hy), then the same shall be extended by Renusagar up to Singrauli by operating the appropriate breaker.

Case (b): Renusagar does not survive:

In case the Renusagar does not survive, then Renusagar shall take the following action to build-up generation at the station.

i) Avail start-up power from Rihand (H) if the units at Rihand (H) are able to self-start and supply is extended by Rihand (H) up to Renusagar.

ii) In case the units at Rihand (H) could not be self started and / or there is some delay in self-starting Rihand (H) units and before that the supply is available at Singrauli 132 KV Bus through Vindhyachal 400 KV link, then Renusagar shall avail start-up power from Singrauli.

iii) The priority for getting the start-up power at Renusagar would be from Rihand (H) followed by Singrauli. Renusagar in this regard would do the necessary monitoring and coordination with the concerned stations.

iv) In case Rihand (H) and Renusagar sub-systems have been synchronized and build-up as a sub-system and Singrauli is being built up as separate subsystem by availing start-up power from Vindhyachal, then also the Rihand (H) and Renusagar sub-system can be synchronized with Singrauli (WR supply) by getting Singrauli supply extended up to Renusagar and synchronization at Renusagar. The synchronization responsibility would be that of Renusagar and the station would achieve this by varying its own generation in consultation with Rihand (H).

3.2.5 Rihand (STPS)

i) Rihand (STPS) shall convey to Singrauli (STPS) its readiness to avail the start-up power and the same shall be obtained from Singrauli on 400 kV Singrauli-Rihand circuit.

ii) After getting the start up power, the station shall light up the units and synchronize the same. [For the specific number of units to be lighted up please also refer Para 3.2.22. (iii)].

iii) Rihand –Dadri HVDC bipole can be started once at least one unit is synchronized at Rihand and there is no constraint at Dadri NTPC end.

iv) Due precaution shall be taken before connecting filter banks at Rihand HVDC prior to energizing the bipole.

3.2.6 Anpara

i) Anpara shall convey to Singrauli (STPS) its readiness to avail start up power and the same shall be obtained from Singrauli (STPS) on 400 kV Singrauli-Anpara line.

ii) In the event of any delay in getting the start up power from Singrauli (STPS) and the same is available at Rihand (Hydro), Anpara shall avail start up power from Rihand (Hy) on 132 kV Rihand (Hy)-Anpara D/C Line.

iii) After getting the start up power, the station shall light up the units and synchronize the same.

iv) Extend start-up power to Obra (Th): 400 kV side, by charging 400 kV Anpara-Obra line.

v) Keep itself ready to extend supply to Sarnath / receive supply from Sarnath, so that WR supply and ER supply can be joined together at Sarnath/Anpara.

Caution: In the event of separate supplies at Singrauli (STPS) and Rihand (Hy), the possible mix - up of supplies extended at Anpara is to be safe- guarded by Anpara. In the event of getting separate supplies at 400kV (from Singrauli) and 132 kV (from Rihand (Hydro)) buses, Anpara is to synchronise these two supplies at its 400 / 132 kV ICT in consultation with Singrauli and Rihand (Hydro).

3.2.7 400 kV Allahabad (PG)

i) Allahabad shall avail Western Region power available at Singrauli through 400 kV Singrauli- Allahabad line.

ii) Maintain voltage at Allahabad 400 kV bus in the range of around 400 kV by using line/bus reactors available at Allahabad.

iii) Extend supply to Kanpur for Railway traction load and start-up power for Unchahar and Panki TPS.

iv) Keep itself ready to extend supply to Sarnath / receive supply from Sarnath, so that WR supply and ER supply can be joined together at Sarnath/Allahabad.

3.2.8 400 kV Kanpur (PG)

i) Kanpur shall avail Western Region power available at

Vindhyachal/Singrauli through 400 kV Singrauli-Allahabad-Kanpur line or alternatively through 400 kV Singrauli-Kanpur line.

ii) Activate SVCs at Kanpur in voltage control mode and by adjusting $V_{reference}$, maintain voltage at Kanpur 400 kV bus in the range of around 390 kV.

iii) Extend supply to Panki for Railway traction load and start-up power for Panki TPS through 220 kV Kanpur-Panki circuit or alternatively through 400 kV Kanpur-Panki circuit.

iv) Extend start -up power to Unchahar TPS on 220 kV Kanpur-Unchahar circuit.

v) Extend supply to Naubasta for Railway Traction load.

3.2.9 Obra (Hy)

i) Self start the units and synchronize with the supply extended from Rihand (Hy).

ii) In case of failure to self-start the units, start-up the units by availing start-up power from Rihand (Hy).

iii) Extend supply to Obra (Th): 220 kV side, in case of start-up power to Obra (Th) cannot be made available from ER supply at Sahupuri.

3.2.10 Obra (Th): 400 kV side

i) Avail start-up power from Anpara through 400 kV Anpara-Obra line and start up the units.

ii) In the scenario of non-receipt of start-up power by Tanda, Charge 400 kV Obra-Sultanpur line for extending start-up power to Tanda. In case of over voltages, the bus reactor at Obra is put into operation and the voltage at Obra 400 kV bus be maintained less than 1.0 pu.

3.2.11 400 kV Panki

i) Panki sub-station to get supply from Kanpur on 220 kV Kanpur-Panki circuit or alternatively through 400 kV Kanpur-Panki circuit.

ii) Extend supply to Railway traction (At Panki, and Sarojini Nagar grid stations).

iii) Extend start-up power to Panki TPS.

iv) In the event of any delay in getting the supply from Kanpur end and availability of the same from Fatehpur end (through Obra-

Allahabad-Fatehpur-Panki route) avail the supply from Fatehpur and extend it for railway traction and start up of unit at Panki TPS.

Caution: After availing the Western Region supply up to Panki, UPPCL shall use it only for railway traction load and start-up of thermal units at Panki. Beyond Panki the power would not be extended by UPPCL on the Western side without specific clearance of NRLDC.

3.2.12 Unchahar

Unchahar shall avail start -up power in the following descending order of priority and revive the units at the earliest:

Priority 1: Kanpur 400 kV - Kanpur 220 kV –Unchahar. (WR supply)

Priority 2: Obra 220 kV-Allahabad - Fatehpur-Unchahar. (ER supply)

3.2.13 Sasaram HVDC (Back to Back Station)

Sasaram HVDC (Back to Back Station) is operating in AC bypass mode i.e. synchronously connected with ER since 1st Dec 2008 in trial mode for finally shifting the HVDC back to back station at some other location. In the event of total loss of power supply at Sasaram, the station would immediately contact NRLDC and 400 kV Sarnath / Allahabad / Biharsharif sub-station to ascertain the status of power supply. In case of total loss of supply in Eastern U.P. (total loss of supply at Sarnath, Kanpur and other neighboring substations), Sasaram shall initiate action for extension of Eastern Region (ER) supply to Sarnath. Sasaram shall finally extend the supply to Sarnath after confirming the readiness from Sarnath end. (The specific operations to be carried out at Sasaram are given under Chapter - 8).

3.2.14 400 kV Sarnath

i) Sarnath shall avail Eastern Region power available at Sasaram through 400 kV Sasaram-Sarnath line.

ii) Maintain voltage at Sarnath 400 kV bus in the range of around 400 kV by using line/bus reactors available at Sarnath/Sasaram. (UPPCL to expedite the revival of breaker at Sarnath for this purpose.

iii) Extend supply to Sahupuri for Railway traction load (if not already available on 220 kV Sasaram-Sarnath line.) and start-up power for Obra TPS.

iv) Extend supply to 400 kV Azamgarh for extension of start-up power to Tanda TPS.

v) Keep itself ready to extend supply to Allahabad or Anpara / receive supply from Allahabad or Anpara, so that WR supply and ER supply can be joined together at Sarnath/Allahabad/Anpara.

3.2.15 220 kV Sahupuri

i) Sahupuri shall avail Eastern Region power available at Sarnath through 220 kV Sarnath-Sahupuri line. (If not already available on 220 kV Sasaram –Sahupuri line)

ii) Extend supply to Railway traction load.

iii) Extend start-up power to Obra TPS through 220 kV Sahupuri-Obra line.

iv) In case of non –receipt of power from Sarnath, avail ER supply from Pusauli and extend the same for Railway traction purposes.

3.2.16 Obra (Th): 220 kV side

i) Avail start-up power from ER supply available at Sahupuri and start up the units.

ii) In the event of non-availability of supply at Sahupuri or there may be considerable delay foreseen in getting supply from Sahupuri, Avail startup power from Rihand (Hy)/Obra (Hy) and start up the units.

iii) Extend power to Allahabad for Railway traction and further extension towards Panki through 220 kV Lines.

Caution: Obra (Th): 220 kV side may get start-up power from any of the two sources viz. from WR through 132 kV Vindhyachal - Singrauli -Rihand (Hy) or from ER through 220 kV Sahupuri. The two supplies which are available at 220 kV Obra from Western or Eastern region, although coming out from a synchronously connected ER-WR system should not be synchronized/joined at Obra unless specifically advised to do so by NRLDC/CLDS, Lucknow. Joining the two supplies at Obra 220 kV may result in large power flow from ER to WR through a weak 220/132 kV link.

More details regarding this aspect has been given at Para 3.2.17 (iv)

3.2.17 400 kV Azamgarh

i) Azamgarh shall avail Eastern Region power available at Sarnath through 400 kV Sarnath-Azamgarh line.

ii) Extend supply to 400 kV Gorakhpur (UP) & 220 kV Gorakhpur (UP) for extension of start-up power to Tanda TPS.

3.2.18 220 kV Allahabad (UP)

i) Allahabad to get supply through 220 KV Obra-Allahabad.

ii) After availing the supplies at Allahabad extend it to Railway traction.

iii) Extend supply to Fatehpur for Railway traction purpose.

iv) In the scenario of non-available of supply at Obra (Th) 220 KV side and the same is available at Fatehpur through Kanpur or Unchahar, avail supply from Fatehpur.

v) Extend supply to Obra (Th) in consultation with UPPCL Control Room, in case Obra (Th) has not received start-up power yet.

3.2.19 220 kV Fatehpur

i) Fatehpur to get supply through 220 kV Obra-Allahabad-Fatehpur

ii) After availing the supplies at Fatehpur extend it for Railway traction.

iii) In case of Panki 220 KV not yet received supply from Kanpur and there maybe inordinate delay in reaching supply at Kanpur, extend supply to Naubasta for Railway traction, Panki for Railway traction and start-up power to Panki (Th) units and Unchahar for starting up the units.

iv) In the scenario of non-availability of supply at Obra (Th)/Allahabad and the same is available at Panki / Naubasta, avail supply from Panki / Naubasta in consultation with SLDC, Lucknow.

v) Extend supply to Allahabad in consultation with SLDC, Lucknow in case the supply at Fatehpur has been received through Panki / Naubasta.

3.2.20 400 kV Sultanpur

i) In case of non-availability of ER supply at Azamgarh, Sultanpur to get power from Obra (Th) over 400 KV Obra-Sultanpur.

ii) Maintain voltage at Sultanpur 400 kV bus in the range of around 400kV by using bus reactors available at Sultanpur.

iii) Extend start up power to Tanda TPS.

3.2.21 220 kV Tanda TPS

Tanda shall avail start-up power in the descending order of priority as given under:

Priority –I: ER supply through 400 kV Muzaffarpur-400 kV Gorakhpur

(PG)-220 kV Basti-220 kV Tanda.

Priority –II: ER supply through 400 kV Sasaram -400 kV Sarnath - 400 kV Azamgarh-400 kV Gorakhpur-220 KV Gorakhpur-220 kV Tanda.

Priority –III: WR supply through 400 kV Vindhyachal-400 kV Singrauli-400 kV Anpara-400 kV Obra-400 kV Sultanpur-220 kV Sultanpur-220 kV Tanda

3.2.22 400 kV Gorakhpur (PG)

i. 400 kV Gorakhpur (PG) shall avail Eastern region power available at Muzaffarpur through 400 kV Muzaffarpur-Gorakhpur or avail power from 400 kV Lucknow (PG) through 400 k V Lucknow (PG)-Gorakhpur (PG) line.

ii. Extend Supply to 400 kV Gorakhpur (UP) for further extending the startup power to Tanda through 220 kV Gorakhpur (UP) Tanda.

3.2.23 400 kV Balia (PG)

i. 400 kV Balia (PG) shall avail eastern region power available at Patna or Biharsharif through 400 kV Patna-Balia or 400 kV Biharsharif Balia.

ii. Or avail power from 400 kV Lucknow through 400 kV Lucknow-Balia.

iii. Extend Supply to 400 kV Mau.

3.2.24 Rosa

Rosa shall avail start - up power from 220 kV Shahjahanpur in the following descending order of priority and r evive the units at the earliest:

Priority 1: 220 kV Unchahar - 220 kV Raibareilly - 220 kV Chinhat - 220 kV Lucknow (PG) – 220 kV Sitapur – 220 kV Shahjahanpur

Priority 2: 220 kV Panki – 220 kV Unnao – 220 kV Lucknow -220 kV Chinhat - 220 kV Lucknow (PG) – 220 kV Sitapur – 220 kV Shahjahanpur

In case the power is available at 400 kV Lucknow (PG) from ER then, It can avail supply through 400/220 kV Lucknow (PG) -– 220 kV Sitapur – 220 kV Shahjahanpur.

General Caution:

i) As per the standing arrangement, in the event of black out in the

Northern Region, support of the order of 100 MW can immediately be availed from the Western Region without undergoing the exercise of exchange of codes etc. and any additional support thereafter would depend on the system conditions persisting at that time in the Western Region and Eastern Region.

ii) While carrying out the restoration in the Northern Region with the help of WR/ER support, at the first instance only the essential load as specified in this document (start up power to the generating units and railway traction feeders etc.) would be en ergized and connection of any other feeders / load can be don e only after looking into the actual availability of power at that moment in consultation with NRLDC.

iii) While working out the requirement of start up power (Para 3.1.4) it has been estimated that initially one 500 MW and one 200 MW unit at Singrauli and Anpara each and one 500 MW unit at Rihand-I and one 500 MW at Rihand-II would be lighted up as soon as start-up power is received at the respective stations. This has been planned on the presumption that to start with around 100 MW power can be availed from WR. However on t he basis of experience from the past disturbances in NR and with favorable conditions prevailing in the WR grid, it is possible that during such] situations larger quantum of power; say up-to 400 MW, may be av ailed from WR and the thermal stations in NR may be abl e to start-up more number of units simultaneously. Therefore, different thermal power stations, particularly Singrauli, Rihand and Anpara must explore the possibility of starting up o f maximum number of units simultaneously after cross checking the power availability aspect from NRLDC/SLDC Lucknow.

iv) **Joining of two supplies i.e. one from WR and other from ER:** In the event of blackout in the Region, the NR can avail start-up power from WR through Vindhyachal AC bypass link, as well as from ER through Sasaram AC bypass link. Check synchronizing of the two supplies extended to NR through WR and ER is desirable, to achieve reliability and redundancy in supply. The supplies from two different sources made available to NR can be joined in NR, as the supplies coming from virtually one source i.e. Central Region or combined Central Grid.

The WR & ER are being operated in parallel and the two regions are synchronously connected through 400 kV Raipur - Rourkela D/C, 400 k V Ranchi-Sipat D/C and 220 kV Korba - Budipadhar T/C.) However, there is likelihood of wheeling of power from ER to WR through NR or vice-versa also, and the quantum of wheeled power can vary depending on system conditions in the three involved regions.

In the course of availing black-start assistance by NR from two neighboring regions, there may be four paths available for synchronizing of WR & ER that can be considered.

Option 'A': **Through 400 kV Anpara**
400 kV Vindhyachal- 400 kV Singrauli- **400 kV Anpara**- 400 kV Sarnath- 400 kV Sasaram.

Option 'B': Through 400 kV Allahabad
400 kV Vindhyachal- 400 kV Singrauli- 400 kV Allahabad- 400kV Sarnath-400 kV Sasaram. Or
400 kV Vindhyachal- 400 kV Singrauli- 400 kV Allahabad- 400 kV Sasaram

Option 'C': Through 132 kV Rihand (Hy) or Pipri
400 kV Vindhyachal- 400 kV Singrauli- 132 kV Singrauli-**132 kV Pipri**- 132 kV Anpara- 400 kV Anpara- 400 kV Sarnath- 400 kV Sasaram.

Option 'D': Through 220 kV Obra 400 kV Vindhyachal- 400 kV Singrauli- 132 kV Singrauli- 132 kV Pipri-132 kV Obra- 220 kV Obra -220 kV Sahupuri- 220 kV Sarnath- 400 kV Sarnath- 400 kV Sasaram.

All the four options have been studied. In different scenario, power flow (Wheeling of power) from ER to WR through NR system (With no load in NR and power flow of 1000 MW from ER to WR through AC interconnections has been considered.) comes out as under,

Option 'A': 350-400 MW (Anpara route)
Option 'B': 300-320 MW (Allahabad route)
Option 'C': 100-110 MW (132 kV Pipri route)
Option 'D': 90-100 MW (220 kV Obra route)

In option 'C' and 'D', although quantum of wheeling of power from ER to WR through NR network is of the order of 100 MW, however, two large and electrically strong ER and WR grid getting connected through a weak 132 kV /220 kV link. Tripping of any element in the serial chain may jeopardize the built-up Eastern UP Subsystem. In view of overall Safety and security of the NR grid, these options may not to be the best one.

In option 'A' and 'B', although, quantum of wheeling of power from ER to WR through NR network is of the order of 300-400 MW, however, the power system network beyond Sasaram in ER and beyond Vindhyachal in WR is generally capable of handling wheeled power of the order of 300-400 MW. Therefore out of the four options listed on previous page, the first two options viz. **option A** and **option B** appear to be the only viable options. Out of these two options also, joining of ER and WR in NR via Allahabad route is preferable in view of the comparatively longer route resulting in controlled power flow and voltage parameters by the time of inter connection. Initially, Eastern UP island can be built-up separately by availing start-up power from ER and WR. Once, the start-up power has been extended to all thermal power station situated in this zone and supply given to railway traction load, the ER and WR supply can be joined together at Sarnath / Allahabad through 400kV Sarnath-Allahabad line. In case of any problem in 400kV Sarnath-Allahabad line the two supplies can be joined together at Sarnath / Anpara through 400kV Sarnath-Anpara line. The rise in voltages at different nodes in Eastern UP Subsystem can be tackled by appropriate use of bus/line reactors available at Singrauli/ Vindhyachal/ Anpara/ Allahabad/ Sarnath/Sasaram etc.

A strict load-generation balance is to be maintained while building up the subsystem, for which a lead role is to be played by UPPCL SLDC Lucknow as well as all generating stations, more particularly Singrauli STPS and Rihand (Hy). Flow on HVDC Rihand Dadri shall also be regulated to meet load generation balance between two sub-systems.

The voltages in the system are be closely monitored and Bus-Reactors / switchable line reactors, SVC are to be promptly utilized by all the major generating stations /grid sub stations for maintaining the system voltages within normal range. (Refer Annex- VI for list of line/bus reactors). Filter banks at HVDC stations shall also be utilized for controlling voltages.

3.3. Synchronization

3.3.1. Synchronization with North-Central (NC) Sub-System

The Eastern U.P. Subsystem shall be synchronized with North-Central (NC) Subsystem through 400 kV Kanpur-Agra line or 400 kV Kanpur-Auraiya –Agra Line or alternatively through 400 kV Kanpur-Ballabgarh line at Kanpur / Agra / Ballabgarh. However, before synchronization of two subsystems, the Eastern U.P. Subsystem preferably is to disconnect from WR/ER keeping into consideration the aspects as stated in the following Para.

3.3.2. Opening of the Vindhyachal Back to Back AC bypass link.

As long as Eastern U.P. subsystem remains connected with WR/ER, the Subsystem enjoys stability by virtue of its connectivity with a large system. However, such connection cannot be continued for an unspecified period due to the possibility of exchange of large and uncontrolled power (during this period there are chances of wheeling of Power by Eastern UP Subsystem from ER to WR and vice-versa, as ER and WR systems are synchronously connected and Eastern UP Subsystem shall become parallel AC path between ER and WR) among the concerned three regions thereby endangering the security of the Western/Eastern Region also.

Opening of the Vindhyachal Back to Back AC bypass link is also important from the point of view of protecting the generation at Vindhyachal from any untoward incident in the recovering eastern UP sub-system and limiting the fault level.

Hence, if the NR system is not already connected with ER on 400 kV Muzaffarpur-Gorakhpur D/C, 400 kV Balia –Patna D/C or 400 kV Balia-Biharsharif- D/C the disconnection of the built-up Eastern U.P. Subsystem from WR/ER is an important activity and its actual timing would have to be decided keeping in consideration the overall system security aspects. The following factors have to be kept in consideration at the time of disconnection.

i) Before disconnection from the WR/ER the following conditions have to be ensured that

a) The Eastern UP Subsystem has been adequately stabilized and built-up to a considerable size (say to a minimum size of around 2000 MW with around 6 generating units from Singrauli, Rihand, Anpara and nearby complex having been synchronized).

b) The Eastern UP subsystem is connected with eastern Region through more than two circuits.

c) The North-Central (NC) subsystem has also been built up adequately and stabilized so that immediately after disconnection from WR/ER, the Eastern U.P. Subsystem can be synchronized with the North-Central (NC) Subsystem.

c) The circuits where the Eastern U.P. Subsystem and North-Central (NC) Subsystem shall be synchronized have been identified and ready for operation.

ii) After the conditions listed at i) above are achieved, the Power flow on the Vindhyachal AC By-pass Link and Sasaram AC By-pass Link has been made in almost floating condition (say less than 20-30 MW). In order to control the flows on AC By-pass Links, the lead role shall have to be played by Singrauli STPS and UPPCL Control Room in consultation with NRLDC, in the following manner:

- By regulating the generation at Singrauli -(Singrauli STPS)
- By regulating the generation at Rihand (Hy) /Anpara (Th)–(UPPCL)
- By getting the load regulated in U.P. System (UPPCL)

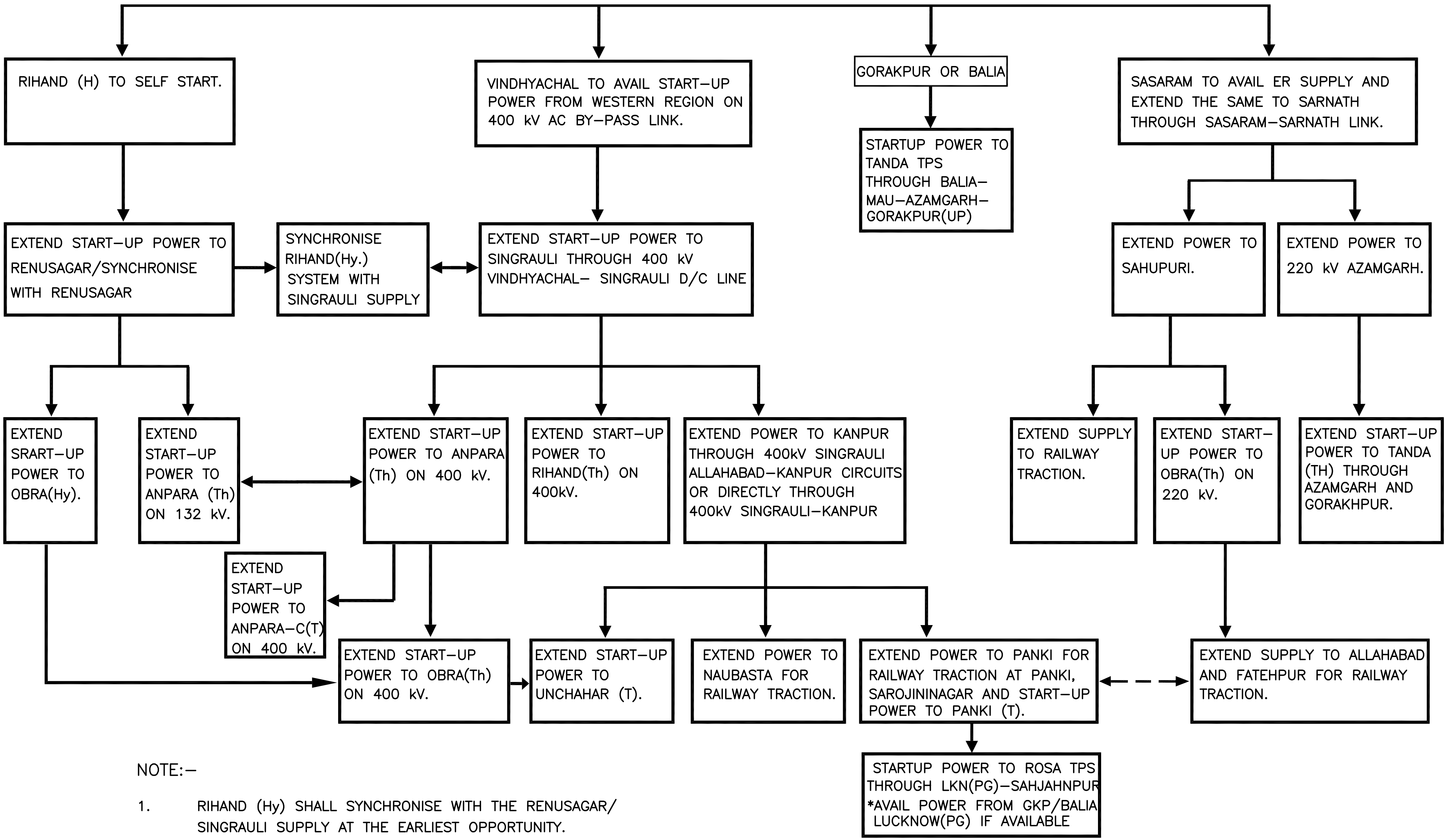
Caution: The above stated sequence suggesting the disconnection of Eastern U.P. Subsystem from WR/ER before synchronization with North-Central (NC) Subsystem is only indicative and based on the “most likely possibility” criteria. However, as the disconnection of the Eastern U.P. Subsystem from WR/ER is a critical and very important activity, while deciding the exact timing and sequence of operations, NRLDC shall consider the actual situation prevailing in the real time and may decide to change the sequence of operations accordingly.

3.4. Start Up Stages And Sequence

i) For different Restoration Stages in Eastern U.P. Subsystem refer **Exhibit-3A**
ii) For detailed Start-up Sequence in Eastern U.P. Subsystem refer **Exhibit-3B**
iii) 132 kV Network around Renusagar **Exhibit-3C**

EXHIBIT – 3A

EASTERN U.P. SUBSYSTEM : RESTORATION STAGES

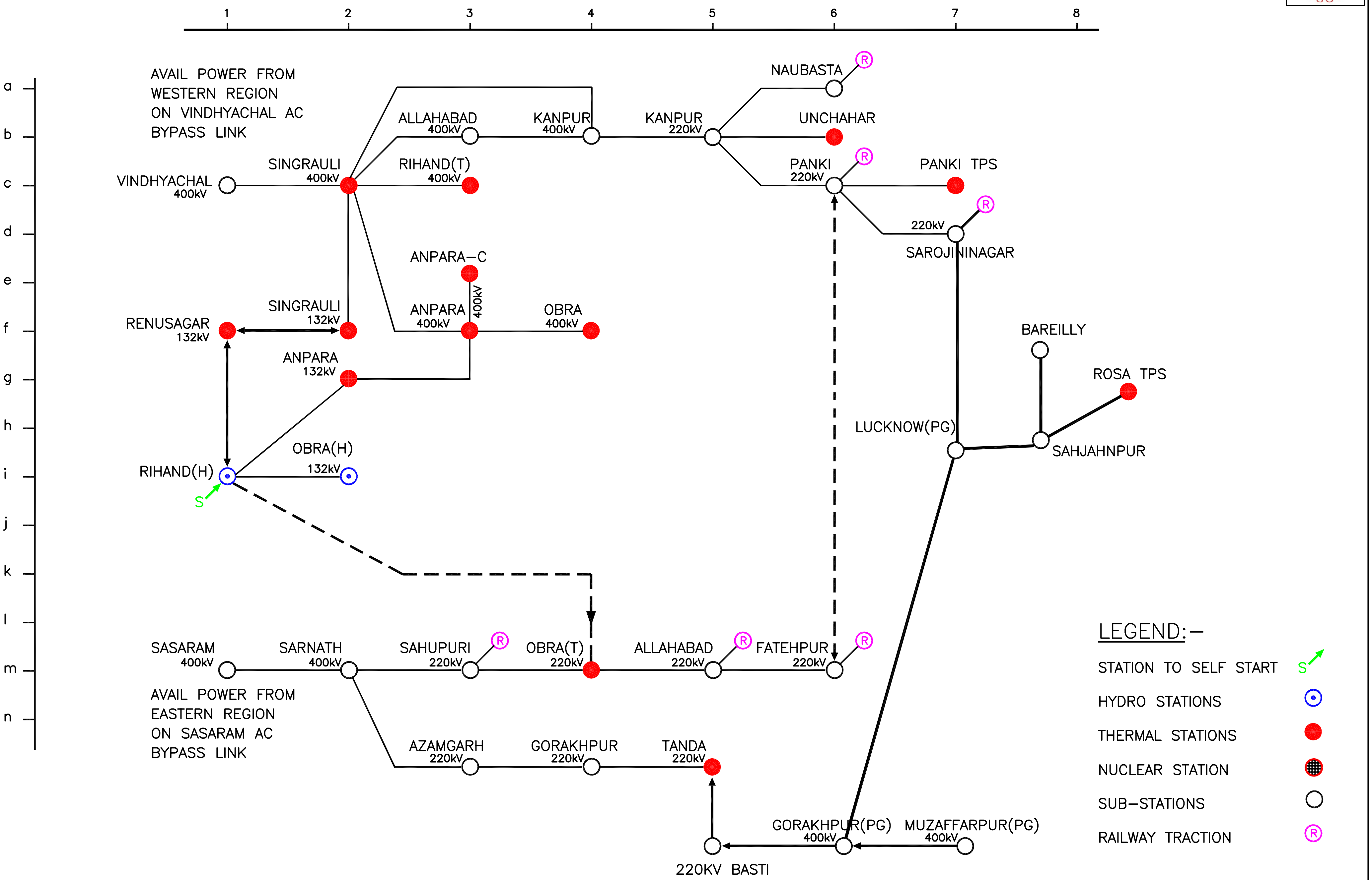


NOTE:–

1. RIHAND (Hy) SHALL SYNCHRONISE WITH THE RENUSAGAR/ SINGRAULI SUPPLY AT THE EARLIEST OPPORTUNITY.
2. EASTERN U.P. SUBSYSTEM SHALL CONTINUE TO OPERATE IN SYNCHRONISM WITH WESTERN/EASTERN REGION TILL THE SUBSYSTEM GETS ADEQUATELY STRENGTHENED.
3. RAILWAY TRACTION SUPPLY AT SAHUPURI SHALL BE FED FROM EASTERN REGION. IN CASE NON RECEIPT OF SUPPLY FROM SARNATH, SAHUPURI SHALL AVAIL ER SUPPLY FROM DEHRI ON 220 kV AND EXTEND THE SAME FOR RAILWAY TRACTION PURPOSE ONLY.

DRN.BY Ramjit | REV.–1 | JANUARY, 2012

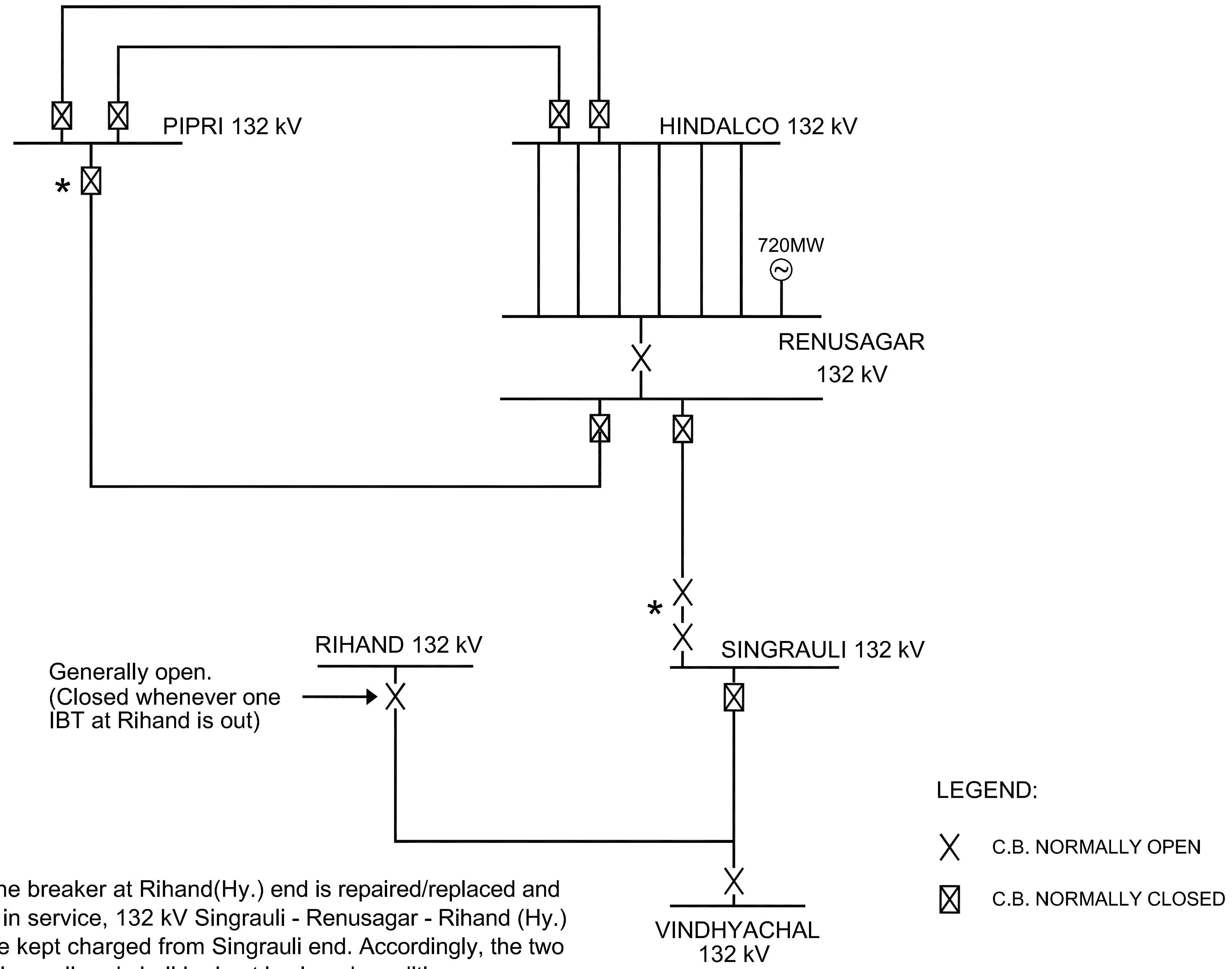
EASTERN U.P. SUBSYSTEM : START–UP SEQUENCE



DRN.BY Ramjit | REV.–1 | JANUARY, 2012

EXHIBIT-3C

INTERCONNECTION OF SINGRAULI, PIPRI AND RENUSAGAR AT 132 kV



* Note:- Till the time the breaker at Rihand(Hy.) end is repaired/replaced and brought back in service, 132 kV Singrauli - Renusagar - Rihand (Hy.) circuit shall be kept charged from Singrauli end. Accordingly, the two breakers at Singrauli end shall be kept in closed condition.

JANUARY, 2012

Chapter-4: Restoration Of North-Central (NC) Subsystem

4.1. Subsystem Overview

North Central sub-system is connected with Eastern U.P. Subsystem and U.P./Uttarakhand Sub-system on its eastern side and Rajasthan Sub-system on its western side within region. It is also connected with western Region. Detailed description of this sub-system restoration is given in this chapter

4.1.1. Important Connecting Links with other Subsystems:

a) With Western U.P./Uttarakhand Sub-system:

1. 400 kV Dadri – Muradnagar
2. 400 kV Agra– Muradnagar
3. 400 kV Mandaula-Meerut D/C
4. 400 kV Mandaula-Bareilly D/C
5. 400 kV Kaithal-Meerut D/C

b) With Eastern U.P. Subsystem:

1. +500 kV HVDC Rihand – Dadri bipole
2. 400 kV Kanpur – Ballabgarh – I
3. 400 kV Kanpur – Ballabgarh – II
4. 400 kV Kanpur – Ballabgarh – III
5. 400 kV Kanpur – Agra (PG) S/C
6. 400 kV Unnao-Agra (UP) S/C
7. 400 kV Allahabad Mainpuri D/C
8. 400 kV Kanpur- Auraiya D/C

c) With Rajasthan Sub-system:

1. 400 kV Bhiwadi-Hissar S/C
2. 400 kV Ballabgarh-Bhiwadi S/C
3. 400 kV Agra-Bassi – I, II & III
4. 400 kV Moga-Bhiwadi D/C
5. 220 kV Chirawa - Hisar
6. 220 kV Dadri (BBMB)-Khetri D/C

d) With Western region:

1. 400 kV Agra-Gwalior - I & II
2. 220 kV Auraiya-Malanpur S/C
3. 220 kV Auraiya- Malanpur

4.1.2. Major Generating Stations:

a) Thermal: Dadri (Th), Ropar, Bhatinda, Lehra-Mohabat, Panipat, DCRTPP, BTPS, Rajghat, RGTPP(Khedar), Indira Gandhi TPS (Jhajjar)

b) Hydro: Bhakra, Dehar, Pong, Salal, Chamera-I & II, Uri, Dulhasti, Bairasiul, Ranjit Sagar, Baspa, Jhakri, Baglihar, Lower Jhelum, Sewa-II, Upper sindh, AD HPP.

c) Gas: Dadri (Gas), Auraiya, Faridabad (Gas), Pragati gas, Delhi GT (Gas), Bawana CCGT, Rithala

4.1.3. Sources of Start-up Power:

a) Bhakra (Right)	300 MW
b) Bhakra (Left)	200 MW
c) Auraiya (Gas)	110 MW
d) Dadri (Gas)	130 MW
e) Delhi GT (Gas)	50 MW
f) Pragati (Gas)	110 MW
g) Pong Hydro	120 MW
h) Faridabad (Gas)	140 MW
i) Salal Hydro	100 MW
j) Dulhasti Hydro	50 MW
k) Uri Hydro	40 MW
l) Baglihar Hydro	50 MW
m) Lower Jhelum Hydro	30 MW
n) Bairasiul Hydro	60 MW
o) AD HPP	40 MW
p) Jhakri	100 MW
q) Karcham Wangtoo	100 MW
TOTAL	**1690 MW**

4.1.4. Requirement of Start-up Power and other Essential Loads:

a) Panipat (Th)	40 MW
b) DCRTPP	50 MW
c) Ropar	50 MW
d) Bhatinda	30 MW
e) Lehra Mohabat-I	50 MW
f) Lehra Mohabat-II	50 MW
g) BTPS	40 MW
h) Dadri (Th)-Stg I & II	90 MW
i) IGSTPS	20 MW
j) RGSTPS	20 MW
k) Rajghat	20 MW
l) Railway Traction	220 MW
m)Other essential load	900 MW
TOTAL	**1610MW**

4.1.5. System Synchronization:

After subsystem build up and stabilization, the North-Central (NC) Subsystem can be synchronized with other subsystems in the following manner:

a) With Eastern U.P. Subsystem: Initially the North-Central (NC) Subsystem shall be synchronized with the Eastern U.P. Subsystem at the following possible connections:
   i) 400 kV Kanpur - Agra (PG) at Kanpur/Agra (PG)
   ii) 400 kV Kanpur - Auriya at Kanpur/Auriya (PG)
   iii) 400 kV Kanpur -Ballabgarh at Kanpur/Ballabgarh

b) With Rajasthan Subsystem: Subsequently the combined North-Central (NC) + Eastern U.P. Subsystem shall be synchronized with the Rajasthan Subsystem at the following possible connections:

   i) 400 kV Bassi-Bhiwadi at Bhiwadi /Bassi
   ii) 400 kV Ballabgarh - Gurgaon at Ballabgarh/Gurgaon
   iii) 400kV Moga-Bhiwadi at Moga/Bhiwadi
   iv) 400 kV Agra-Bassi at Bassi/Agra

c) With Western U.P. Subsystem: Finally, the combined North-Central (NC) + Eastern U.P. + Rajasthan Subsystems shall be synchronized with the Western U.P. subsystem at the following possible connections:

   i) 400 kV Dadri-Muradnagar at Dadri / Muradnagar
   ii) 400 kV Agra-Muradnagar at Agra / Muradnagar
   iii) 400 kV Panki-Muradnagar at Panki / Muradnagar
   iv) 400 kV Bareilley-Moradabad at Bareilley/ Moradabad
   v) 400 kV Bareilly-Mandaula at Bareilly/Mandaula
   vi) 400 kV Meerut-Mandaula at Meerut/Mandaula
   vii) 400kV Meerut-Kaithal at Meerut/Kaithal

The above synchronizing sequence is only indicative. However, based on the actual electrical size and geography of a particular subsystem being built-up, the sequence of synchronization of different sub-systems can be suitably decided based on the real time conditions.

4.2. Subsystem Restoration Procedure

4.2.1. The North-Central (NC) sub system:

The North-Central (NC) Subsystem at the time of build-up shall be considered to have consisted of the following main areas:

i) **Delhi area** - consisting of generating units in Delhi System (including BTPS) and Faridabad (Gas).

ii) **BBMB and neighboring area** - consisting of the hydro units of BBMB, thermal and hydro units of Punjab & Haryana and hydro units of H.P. (including hydro units of IPPs viz. Baspa, Malana, AD HPP etc.)

iii) **Dadri (NTPC) area** – consisting of units at Dadri (Gas and Dadri (Thermal) along with traction load being catered at Dadri.

iv) **Auriaya (Gas) area** - consisting of Auraiya (Gas) along with traction load at Agra / Mathura / Phaphund.

v) **J & K And North Punjab area -** consisting of hydro units in J & K, North Punjab and Chamera, Salal , Uri, Dulhasti and Baglihar power house of NHPC. At the time of subsystem built-up, the actions to be taken at the major Generating stations / grid substations in the North-Central (NC) Subsystem are as given below.

4.2.2. Delhi area

i) In case of survival of Delhi inner ring, Delhi shall immediately extend start-up power to Badarpur. In order to strengthen the survived network, it shall be synchronized, at the earliest, with the supply from Faridabad (Gas) on 220 kV Ballabgarh- BTPS Ckt. at BTPS.

ii) In case of collapse / non-survival of Delhi inner ring, the Delhi GT's machines / Pragati GTs / Bawana CCGT are to be self-started and supply is to be extended for meeting the emergency loads, to Badarpur as start-up power and to Park Street for railway traction. DTL has to ensure that Rajghat units are also extended power at the earliest suitable opportunity. The built-up system would be synchronized with the supply available from Faridabad (gas) at the first opportunity.

iii) As soon as stabilized power supply from the BBMB Subsystem is available at the periphery of Delhi (say at Ballabgarh / Mandaula), the Delhi Area (consist of generating units in Delhi system, Faridabad gas and BTPS) shall synchronize with the same.

4.2.2.1. Faridabad (Gas)

i) Faridabad GPS would self start GTs and extend supply to BTPS via 220 kV Faridabad - Samaypur – Ballabgarh– BTPS (supply would be extended from Faridabad to BTPS on priority without putting any additional load except 30-40 MW load at Samaypur and traction load at Ballabgarh).

ii) To give stability to Faridabad GPS, controlled load in a gradual manner would be put at Okhla feeders from BTPS. In the event of drop in frequency, load to be shed immediately in this island, in a gradual manner, and maintain the load-generation balance in the island.

Caution

i) In order to maintain the load - generation balance in the built up area and to avoid sharp variations in the loading of Faridabad (GTs), the load in Delhi system would be added / removed in a controlled and gradual manner. Necessary coordination / control in this respect shall be carried out by DTL, in coordination with BTPS, Faridabad (gas) and NRLDC.

4.2.2.2. Badarpur (Th) Power Station (BTPS)

BTPS shall avail start-up power in the following order of priority:

Priority 1: From Faridabad GPS via 220 kV Faridabad (GPS) – Samaypur – Ballabgarh – BTPS

Priority 2: From Pragati GTs

Priority 3: From Bawana CCGT

Loading in the built up area shall be controlled by DTL.

Priority 4: BBMB power via 220 kV Panipat – Narela (DTL) – Bawana – Najafgarh- Bamnauli- Mehrauli – BTPS DTL will add load at any of the above en-route substations after the supply is available at Narela in an extremely controlled and judicious manner in consultation with NRLDC and keeping a close watch on the system parameters (The 30-40 MW load at Narela for Railway Traction purpose would be provided on priority).

Priority 5: BBMB power via 400 kV Panipat - 400 kV Dadri – 400 kV Samaypur-220 kV Samaypur – 220 kV Ballabhgarh-220 kV BTPS

Priority 6: BBMB power via 220 kV Panipat – Charkhi Dadri –

Ballabgarh – BTPS.

4.2.3. BBMB and Neighboring Area:

i) The units at Bhakra (R) or Bhakra (L) shall be self-started and the supply shall be extended to Ganguwal.
ii) From Bhakra (R) supply shall be extended to Jamalpur & Bhakra (L); the supply shall be extended to NFL.

iii) From Ganguwal the supply shall be extended to units at Bhakra (L) / Bhakra (R) as the case may be, and around three (3) machines each at Bhakra (R) and Bhakra (L) would be operated to provide adequate spinning reserves & dynamic reactive resources for the weak system.

iv) From Ganguwal supply shall be extended to Ganguwal HEP & Kotla HEP at 132 kV and units at these stations would be synchronized.

v) From Kotla 132 kV supply shall be extended to Ropar TPS (via Ropar 132 kV) for start up of units.

vi) From Ganguwal supply shall be extended to Panipat 220 kV through Dhulkote.

vii) From Ganguwal the supply shall be extended to Dehar HEP and units at Dehar would be synchronized.

4.2.3.1. Panipat 220 kV (BBMB)

After availing power from Ganguwal over the 220 kV Ganguwal-Dhulkote-Panipat section. Following actions shall be taken at Panipat 220 kV (BBMB):

1. Extend power to Panipat (Th) stage -I.
2. Extend power to Narela & panipat for Railway Traction load.
3. Charge one 220 kV / 400 kV ICT at Panipat and then charge 400 kV line to Dadri.

4.2.3.2. Panipat (Th)

Panipat-(Th) stage-I shall avail startup power from Ganguwal through Panipat BBMB.

Panipat-(Th) stage-II shall avail startup power from Ganguwal through Panipat BBMB by connecting the bus coupler between stage I and stage-II.In case of difficulty in connecting with Panipat stage-I, it can avail startup power from 400 kV Kaithal, or 400 kV Bahadurgarh, or 400 kV Hisar or 400 kV Abdullapur , depending on the availability of supply.

4.2.3.3. DCRTPP (Yamuna Nagar Th)

DCRTPP (Ropar Th) shall get start up power from Jhakri/Baspa system through Abdullapur (PG) route. In case of non availability of startup power through this route it should attempt to avail startup power from 400 kV Kaitahl (PG) or Hissar (PG).

4.2.3.4. Indira Gandhi SSTPS (Jhajjar)

I. Blackstart of Bawana CCGT through Mundka

II. From supply at Ballabgarh through Bamnauli-Mundka

III. Both supply at Gurgaon through Daulatabad

4.2.3.5. Rajiv Gandhi TPS (Kheddar)

I. From black start of chamera through Moga

II. Through supply at Hisar – Fatehabad

III. Through 220kV network of Haryana

IV. 220kV system of BBMB/ Haryana

V. Bhakra supply at jamalpur-sangrur-Hisar-Kirori.

4.2.3.6. Ropar (Th)

Ropar (Th) shall get start up power in the following descending order of priority:

Priority 1: Bhakra (R)/ (L) -Ganguwal - Ganguwal (132 kV)-Kotla-Ropar- Ropar (Th)

Priority 2: Bhakra (R)/ (L) – Ganguwal - Mohali- Ropar (Th)

Priority 3: Bhakra (R)/ (L) - Ganguwal- Govindgarh II– Govindgarh I – Ropar (Th)

Priority 4: Bhakra (R) – Mahilpur-Jamsher-Ropar (Th)

From Ropar power shall be extended to Anandpur Sahib HEP at 132 kV and the generating units at Anandpur Sahib HEP shall be synchronized.

As soon as 220 kV Nallagarh-Mohali circuit becomes available that is under advance stage of commissioning Jhakri supply can be extended to Ropar through 400 kV Jhakri- Nalagarh-220 kV Nallagarh- 220 kV Mohali-Ropar route.

4.2.3.7. Bhatinda / Lehra Mohabat

Bhatinda / Lehra-Mohabat shall get start up pow er in the following descending order of priority:

Priority 1: Bhakra (R) –Jamalpur- Sangrur- Barnala (BBMB)-Lehra Mohabat -Bhatinda;

Priority 2: Bhakra (R)/(L)- Ganguwal- Govindgarh-II- Govindgarh-I Malerkotla –Barnala (PSEB) – Lehra Mohabat- Bhatinda

4.2.3.8. Pong

I. Pong machines shall self start and be r eady for synchronization.

II. Synchronize with BBMB supply extended to Pong via Bhakra (R) - Jamalpur- Jallandhar- Pong.

III. In case of difficulty in self start, use the available BBMB supply or supply from Bairasiul for start-up of the units.

IV. In case of units at Bairasiul could not be started, extend start-up power to Bairasiul.

4.2.3.9. Bairasiul

I. Self- start the units and extend supply to Pong if required.

II. In case of any problem in self-starting the units, avail BBMB supply from Pong and start the units.

III. Extend supply to Jessore.

4.2.3.10. ADHPP

I. Self start & extend supply to UT, Chandigarh & mohali.

II. In case of failure of black start get supply from Nalagarh & start.

4.2.3.11. Baspa

I. Self- start the units and extend supply/ synchronize to/with Jhakri.

II. In case of any problem in self-starting the units, avail supply from Jhakri and start the units.

4.2.3.12. Jhakri

I. Self- start the units and extend supply to 400 kV Abdullapur for catering Railway traction load and other essential load in that area. [Alternately once 220kV Nallagarh-Mohali line is commissioned, 400 kV Jhakri –Nallagarh line can be charged after self starting the units to extend supply to Mohali & UT Chandigarh on 220 kV circuits.

II. Synchronise with the supply extended from Baspa. In case of machines at Baspa could not be started, extend supply to Baspa.

III. In case of any problem in self-starting the units, avail supply from Baspa and start the units.

IV. In the event of non-availability of supply in Baspa/Jhakri area, the BBMB supply shall be extended to this area through Panipat (Th)-Narwana-Kaithal-Pehowa-Shahabad-Abdullapur 220 kV - Abdullapur 400 kV-Jhakri 400kV.

4.2.4. Dadri (NTPC) area

I. In case the GT's at Dadri survive on house load, then Dadri (Gas) would extend start up power to Dadri (Thermal) through 220 kV interconnection and **extend supply to railway traction load.**

II. In the event of tripping of all the GT's at Dadri, these shall be self started and start up power would be extended to Dadri (Th). **Supply shall be extended to railway traction load on priority.**

III. In the event of build up of the Dadri area by self starting the units at Dadri (Gas) and synchronization of unit(s) at Dadri (Thermal), the supply shall be extended up to Dadri 400 kV for synchronization with BBMB supply at 400 kV Dadri - Panipat Ckt. The supply shall also be extended to 400 kV Ballabgarh for extending power/ synchronization with Delhi Area.

IV. In the event of any difficulty in self-starting the GTs at Dadri (gas) and/or extending the supply to the units at Dadri (Th), BBMB supply shall be extended to Dadri 400 kV sub-station for start-up of generating units, through Panipat 220 kV -Panipat 400 kV -Dadri 400 kV.

V. Due precaution with respect to voltage control in and around Dadri NTPC shall be taken before connecting the base filter banks at Dadri HVDC for restoration of HVDC Rihand –Dadri bipole.

4.2.5. Auraiya (Gas) area:

4.2.5.1 Auraiya Gas

I. The GT's at Auraiya are shall be self-started. However, the power flow on t he 220 kV Auraiya-Malanpur link shall be maintained close to zero or as permitted by MP/WRLDC so that no adverse effect shall be experienced by the WR system in and around Malanpur and Auraiya GPP shall achieve such conditions by controlling generation at Auraiya.

II. From Auraiya supply shall be extended to 220 kV Phaphund for railway traction load.

III. From Auraiya supply shall be extended to 220 kV Sikandara for railway traction load at Agra and M athura and to 400kV Agra (PG) substation through 400kV Agra (UP) for synchronization with North-Central subsystem.

IV. The Auraiya (gas) area shall be s ynchronized with the North-Central (NC) Subsystem at Agra (PG) 400 kV.

Caution

In case of failure in self-starting of GT's at Auraiya, the same can be started by availing start up supply in the following descending order of priority

Priority-1: Western Grid supply from Malanpur.
Priority-2: Western Grid supply from Gwalior through 400 kV Gwalior-Agra-Auraiya route.
Priority-3: North-Central (NC) subsystem supply through Ballabgarh-Agra -Auraiya 400 kV route.

4.2.5.2 400 kV Agra (PG)

1. 400 kV Agra shall avail supply from Western region through 765 kV Agra Gwalior (charged at 400 kV).

2. It should extend startup power to Auraiya Gas through 400 kV Agra (PG)-Auraiya D/C.

3. It should extend supply to Rajasthan subsystem through 400 kV Agra-Bassi-Heerapura route.

4.2.6. J&K and North Punjab Area

Action to be taken at the major generating stations / grid sub-stations in J & K and North Punjab Area is as given below:

4.2.6.1 Ranjit Sagar HEP

I. Generating units at Ranjit Sagar HEP shall be self started and from this load around Sarna shall be fed. When BBMB supply is extended to Sarna through Jallandhar and Dasuya, the supply from Ranjit Sagar HEP shall be synchronized with the BBMB supply at Sarna.

II. From Sarna power shall be extended to Kishenpur and synchronized with the supply from Salal / Chamera. Alternatively if the stabilized supply at Kishenpur is built up early then it shall be extended up to Sarna for synchronization with BBMB / North Punjab System.

Note: PSEB shall develop synchronizing facility at its 220 kV Sarna Substation in order to synchronize the different subsystems built up in J & K Area, BBMB Area and Northern Punjab.

4.2.6.2 Salal HEP

I. Salal shall self-start its units and extend supply to Jammu.

4.2.6.3 Chamera HEP

Chamera-I HEP

i. Chamera-I shall self start its units and extend supply / synchronized with Chamera II.

ii. The supply of Chamera-I shall be extended to 400 kV Jallandhar and further to 220 kV Kotlajunga and 220 kV Kartarpur for load.

iii. The supply of Chamera-I can be synchronized with grid supply at Jallandhar.

Chamera-I HEP

i. Chamera II shall self start its units and extend supply / synchronized with Chamera I.

ii. The combined supply of Chamera I & II shall be extended to 400 kV Kishenpur or 400 kV Jallandhar.

4.2.6.4 Uri

i. Uri shall self start its units and extend supply to Wagoora.
ii. In case of difficulty in self starting it should avail startup supply from Wagoora (if available.)

4.2.6.5 Lower Jhelum

Lower Jhelum shall self start its units and extend supply to Ziankote via Pattan for synchronization at Wagoora / Ziankote with other available supply in valley.

4.2.6.6 Baglihar

Baglihar shall self start its units and extend supply to Kishenpur that can be further extended for startup supply in the valley to Uri or Lower Jhelum.

4.2.6.7 Dulhasti

Dulhasti shall self start its units and extend supply to Kishenpur that can be further extended for startup supply in the valley to Uri or Lower Jhelum.

4.2.6.8 400 kV Kishenpur

i. 400/220 kV Kishenpur substation becomes a pooling station for supply from Jammu, Valley and North Punjab area. Therefore, due precaution shall be taken in carrying out switching operation at Kishenpur.

ii. The generating units at three hydro stations around Jammu and North Punjab area viz. Salal, Ranjit Sagar and Chamera shall be self started and supply shall be extended to Kishenpur and synchronized. In the event of any difficulty in self-starting the units at any station, supply from Kishenpur shall be extended to the concerned station.

iii. Power from BBMB Complex shall be al so extended to 220 kV Kishenpur sub-station in the following sequence:

Bhakra (R) - Jamalpur – Jallandhar – Dasuya – Sarna – Kishenpur and the two supplies shall be synchronized.

iv. From Kishenpur supply shall also be extended to Pampore in case of non-availability of supply from Hydro units in the valley area.

4.2.6.9 Bhiwadi HVDC

400kV Bhiwadi is a terminal station for HVDC Balia-Bhiwadi. This is connected to 400kV Agra(P.G), 400kV Hisar, 400kV Moga, 400kV Bassi & 400kV Gurgaon. To maintain suitable voltage profile at Bhiwadi precaution has to be taken for usage of filter banks.

4.2.6.10 RGTPP (Khedar)

RGTPP is connected to the grid at Fatehabad & Kirori only through 400 lines.

4.3. Synchronization

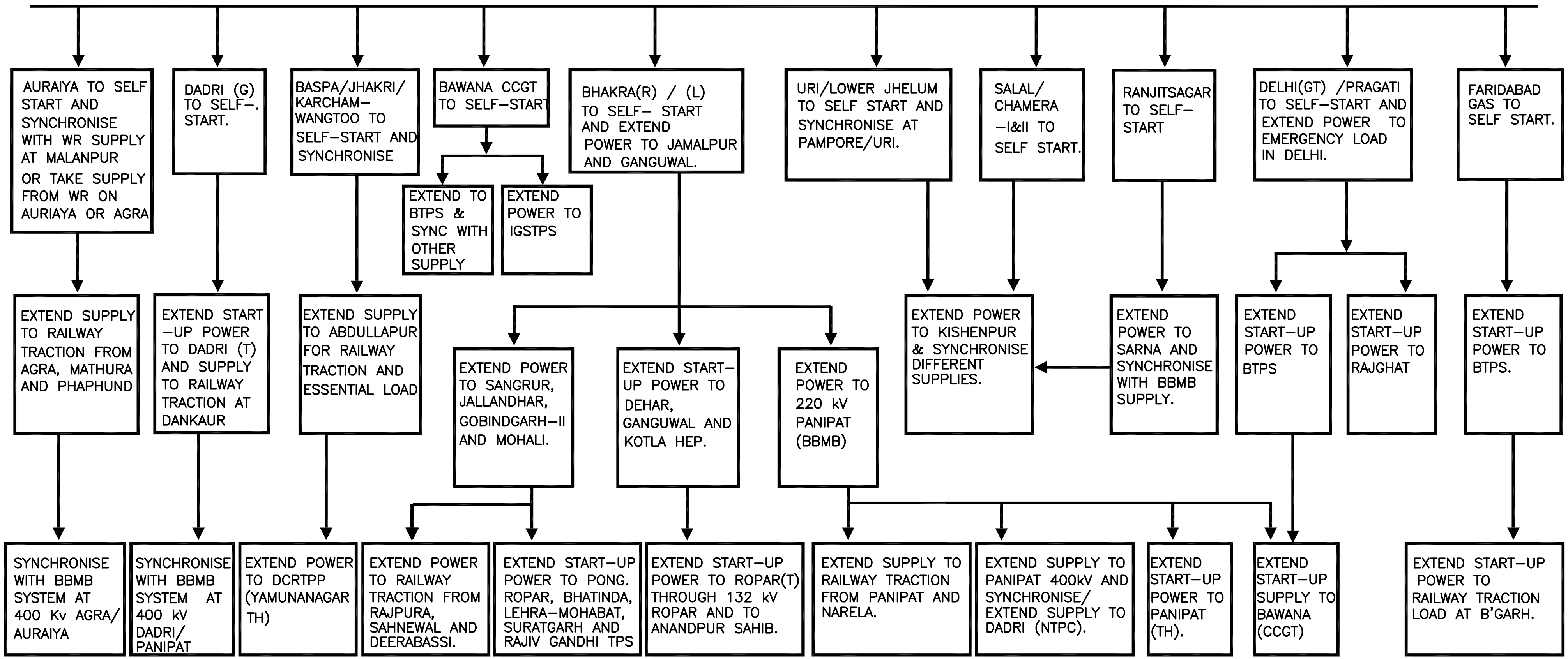
The North-Central Sub-system shall be synchronized with the Eastern U.P. Subsystem through 400 kV Kanpur-Agra Ckt. at Kanpur / Agra or alternatively through 400 k V Kanpur - Ballabgarh Ckt. at Kanpur/ Ballabgarh The combined subsystems shall also be synchronized with the Rajasthan and Western U.P. Subsystem.

4.4. Start-Up Stages and Sequence:

I. For different Restoration Stages in North-Central (NC) Sub-system refer **Exhibit-4A.**
II. For detailed Start-up Sequence in North-Central (NC) Sub-system refer **Exhibit-4B.**

EXHIBIT – 4A

NORTH CENTRAL SUBSYSTEM : RESTORATION STAGES



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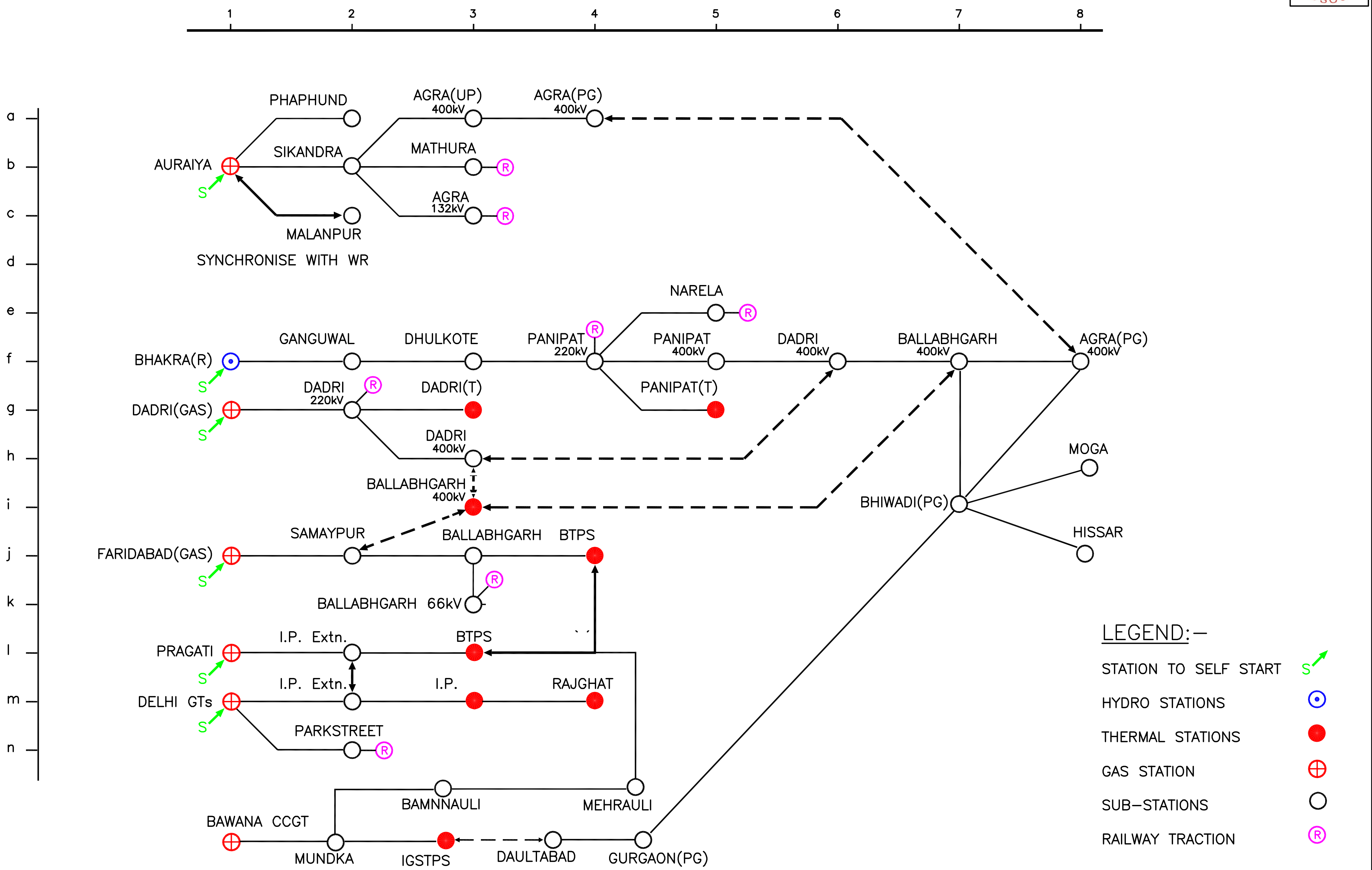
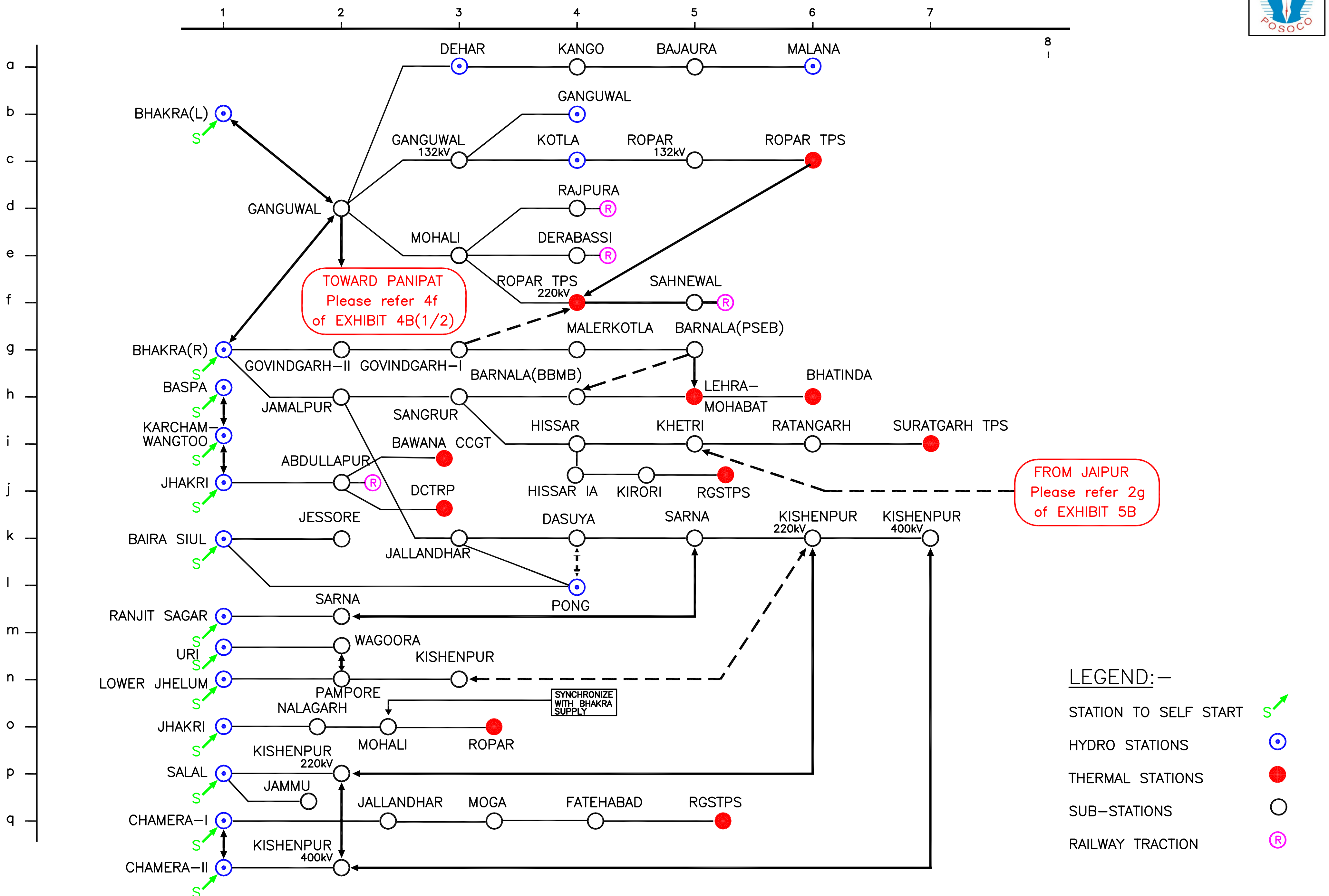
NORTH–CENTRAL SUBSYSTEM (PART–1): START–UP SEQUENCE



NORTH–CENTRAL SUBSYSTEM (PART–2): START–UP SEQUENCE



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Chapter-5: Restoration of Rajasthan Subsystem

5.1. Subsystem Overview:

Rajasthan sub-system is connected with North - Central sub-system on its eastern side within region. It is also connected with western region. Detailed description of this sub-system restoration is given in this chapter

5.1.1. Important Connecting Links with other Subsystems:

a. With North-Central (NC) subsystem
   1. 400 kV Gurgaon - Bhiwadi
   2. 400 kV Hissar – Bhiwadi
   3. 400 kV Moga - Bhiwadi
   4. 400 kV Agra – Bassi - I, II & III
   5. 400 kV Agra – Bhiwadi I & II
   6. 220 kV BTPS Alwar
   7. 220 kV Agra(UP)-Bharatpur
   8. 220 kV Chiwara-Hisar
   9. 220 kV Dadri Khetri D/C

b. With Western Region
   1. 400kV Zerda-Bhinmal
   2. 400kV Zerda – Kankroli
   3. 220 kV Kota-Badod-Ujjain
   4. 220 kV Morak-Badod-Ujjain

5.1.2. Major Generating Stations:

a) Thermal: Suratgarh STPS, Kota STPS, Giral LTPS, Barsigsar, Chabra , JSW, Rajwest, Venkaya LTPS
b) Hydro: Rana Pratap Sagar (RPS), Jawahar Sagar (JS), Mahi Bajaj Sagar Ph I & II.
c) Gas: Anta, Dholpur (CCPP), Ramgarh GTPP
d) Nuclear: RAPS (A), RAPS (B) , RAPP (C)
e) Wind generation: Jodhpur/ Jaisalmer area

5.1.3. Sources of Start-up power

a) RPS -Self start:	86 MW
b) JS HEP- Self start:	66 MW
c) Anta (Gas):	80 MW
d) Ramgarh GT:	40 MW
e) From WR on Badod Morak / Kota link	100 MW
f) From BBMB system at Khetri	100 MW
g) From W.R to Kankroli	100MW
Total:	**572 MW**

5.1.4. Requirement of Start-up power:

a)	Suratgarh STPS	70 MW
b)	Kota STPS:	70 MW
c)	RAPS (A) RAPS (B) & RAPS (C)	75 MW
d)	Giral Lignite	20 MW
e)	Chabra TPS	25 MW
f)	V.L TPS	20 MW
g)	JSW	20 MW
h)	Barsingsar	20 MW
i)	Railway Traction	70 MW
j)	Other Essential Loads	142 MW
	Total:	**572 MW**

5.1.5. System Synchronization:

After build-up of the Rajasthan Sub-system, it can be synchronized with the combined North-Central (NC) and Eastern U.P Subsystems or only with North-Central Subsystem as per situation at the following possible connections.

i) 400 kV Hissar-Bhiwadi at Hissar/Bhiwadi
ii) 400kV Moga-Bhiwadi at Moga/Bhiwadi
iii) 400 kV Agra-Bassi at Agra/Bassi
iv) 400 kV Ballabgarh-Gurgaon at Ballabgarh/Gurgaon

5.2. Subsystem Restoration Procedure

At the time of subsystem build up, the action to be taken at the major generating stations / grid substations is as given below:

5.2.1. R.P.Sagar HEP

i) R.P.Sagar HEP shall self-start and synchronize with WR supply on 132 kV R.P.Sagar-Gandhi Sagar line for stabilization.
ii) In case of any problem in self-starting of units at R.P. Sagar, avail start-up power from Gandhi Sagar (WR) and start the units at R.P.Sagar.
iii) Extend start-up power or receive power from Jawahar Sagar as the case may be.
iv) Extend supply to Kota (S)

5.2.2. Jawahar Sagar HEP

Jawahar Sagar HEP shall self start the units and ex tend power to R.P.Sagar. In case of problem in self-starting the units, avail start-up Power from R.P.Sagar and start-up its units.

5.2.3. Kota (Sakatpura) 220 kV Sub-Station

i) Avail power from Ujjain (WR) on 220 kV Badod-Kota circuit and start-up power shall be extended to Kota (STPS), RAPS (A) and RAPS (B). Simultaneously synchronization with the supply from R.P. Sagar shall also be carried out.

ii) In case start-up power from Ujjain is not available, Kota (S) shall avail the power from RP Sagar and extend it to Kota (STPS), RAPS (A) and RAPS (B).

iii) Extend power supply for Railway Traction.

iv) Synchronize with supply extended from survived RAPS (A) /RAPS (B) islands.

v) Synchronise with supply extended from Anta or, in case request received from Anta, start-up power / reference shall be extended from Kota (S) to Anta, in consultation with SLDC control room.

vi) Extend supply from Dhara to Chhabra.

vii) Extend supply to Jaipur for other essential load.

5.2.4. Kota (STPS)

i) Kota (STPS) to avail start-up power from Morak or from Kota (S).

ii) Extend supply to Jaipur, in case of supply could not be extended to Jaipur through Kota (S).

iii) Alternatively Kota (STPS) can avail start-up supply from 400 kV Heerapura (if available).

5.2.5. Giral Lignite

i) Giral Lignite shall avail start-up power from Ramgarh GT through 132 kV Ramgarh- Jaisalmer-Barmer-220 kV Giral route or through 220 kV Ramgarh-Amarsagar-Mada-Barmer route...

ii) Or alternatively, it should avail startup power from 400 kV Jodhpur through Jodhpur-Balotra-Barmer-Giral route.

iii) Or alternatively WR supply at Bhinmal through Bhinmal-Dhaurimanna-Barmer-Giral.

5.2.6. RAPS (A) , RAPS (B) and RAPS (C)

i) In case of survival of either of RAPS islands, extend supply to Kota

(S) and synchronise with Kota (S) once the supply around Kota (S) has been stabilized.

ii) In case of tripping of RAPS (A), avail start-up power from Kota (S). In case of non-availability of power from Kota (S) / RP Sagar, RAPP(A) shall initiate action to draw power from Western Grid by charging 132/220 kV, 50 MVA transformer at RAPP(A) through 132 kV Gandhi Sagar-RP Sagar line.

iii) In case of tripping of RAPS (B). avail start-up power from Kota. (S). In case of any problem in RAPS (B)-Kota (S) ckt, the start-up power can be availed through Anta-RAPS (C) route.

iv) In case RAPS (B) survives, then, in consultation with SLDC control Room, it shall extend power to Anta for starting of GTs /synchronization.

v) RAPS (C) shall avail start up power from 220 kV Kota (S)-RAPP (B)-RAPP (C) route or through 220 kV Anta- RAPP (C) route.

vi) In case of startup power at Kankroli from zerda(W.R), start up to RAPP(C), RAPP(A) & RAPP(B) through 220kV Debari.

5.2.7. Anta (Gas)

i) In case, Anta has survived on house load, extend supply to Kota (S) for synchronization/build-up of system. Alternatively self-start or receive the supply from Kota (S) / RAPS (B), if 220 kV Kota (S) / RAPS (B) buses are in charged condition. The two supplies also to be synchronized at the earliest opportunity.

ii) In case of tripping of units at Anta, self start GT's at Anta and extend supply to Kota (S) and RAPP (C)

iii) In case of any problem in self starting of units at Anta or extending supply to Kota (S), request Kota (S) to extend supply and start GT's /synchronise.

iv) Extend supply from Anta to Sawai-Madhopur, Dausa, Bharatpur and Hindun for Railway Traction load.

Note:

1. NTPC-NCR informed that Anta can extend power once line is charged from other end. As per the feasibility studies carried out by engineering of NTPC for charging RAPP line from Anta and extend supply to RAPP it is observed that for Anta loading rate is 6.0 MW/min and the load requirement of RAPP is step load and not gradual loading. Therefore, it is not technically feasible to cater to the starting power requirement of RAPP by Anta GPS on

commitment basis.

2. For starting power of Kota STPS, due to long line & possibility of close communication not feasible with Kota STPS for regulating GT loading, it is difficult to extend only from Anta GPS. Hence NTPC-Anta can extend power once line is charged from other end

5.2.8 Dholpur CCPP

i) Dholpur shall avail startup power from Bassi through 220 kV Bassi-Hindaun-Dholpur route or through Bassi-Dausa-Bharatpur-Dholpur route.
ii) In case of difficulty in getting startup power through Bassi try to avail startup power from Agra (UP) on 220 kV Agra-Bharatpur-Dholpur route.

5.2.9 Ramgarh GTPP

i) Self start the units at Ramgarh and
ii) Extend startup power to Giral LTPS through 220 kV Amarsagar or 132 kV Jaisalmer route.

5.2.10. Suratgarh STPS

Suratgarh STPS shall avail start-up power in the following descending Order of priority:

Priority-1: From BBMB System through Bhakra ® – Jamalpur-Sangrur- Hissar- Khetri- Ratangarh- Suratgarh route.

Priority-2: From Rajasthan Subsystem through Kota (S)-Jaipur-Khetri- Ratangarh- Suratgarh route.

5.2.11 Barsingsar (IPP)

I. Blackstart of Ramgarh & if margin is available through 220kV Amasagar-Phalodi-Barsingsar.

II. Supply from Khetri-Ratangarh-Bikaner-Barsingsar.

III. Supply from Merta through 220kV Nagaur & 220kV Nokha

5.2.12 Chabra TPS

I. Avail start-up power from Morak through Jhalawar

II. Or avail start up power from Kota(s) through Dhahra

III. Or alternatively take supply from Heerapura if available

5.2.13. V S Lignite (IPP)

I. If margin available black start supply from Ramgarh GT through 220kV Amarsagar-Phalodi-Barsingsar-Bikaner.

II. BBMB supply through Khetri-Ratangarh-Bikaner.

III. Supply at Merta through 220kV Merta-Nagaur-Nokha-Barsingsar

5.2.14. Rajwest LTPS

I. Black start Ramgarh GT's through 132kV Jaisalmer-Barmer-220 Barmer-Rajwest

II. Or through 220kV Amarsagar-MADA-Akal-Barmer-Rajwest

III. Supply from W.R at Bhinmal through Bhinmal-Dhaurimana-Rajwest.

IV. Or alternatively jodhpur supply through Jodhpur-220kV Balotra-Barmer- Rajwest

5.2.15 Jaipur (Heerapura) 220 kV Sub-Station

i) Avail power supply from Kota (S)/Kota (STPS).

ii) Extend power to Dausa and Bharatpur for Railway Traction and other emergency loads.

iii) Extend power to Khetri for further extension to Suratgarh as startup power, in case there is delay in getting BBMB supply at Khetri.

iv) Extend power to Jaipur (Heerapura) / Bassi 400 kV substation for synchronization of Rajasthan Subsystem with North-Central (NC) Subsystem.

5.2.16. Khetri 220 kV Sub-Station

i) Khetri shall get BBMB supply from Hissar and start up power shall be extended to Suratgarh.

ii) In case there is delay in getting BBMB supply then Khetri shall avail power through Jaipur from Rajasthan Subsystem and extend it to Suratgarh.

Caution

I. While restoring the Subsystem, the load generation balance is to be maintained.

II. In case of survival of RAPS (A)/RAPS (B) islands, these must be synchronized with the supply of R.P Sagar / Kota (S) at the earliest opportunity.

III. The power supply to Railway Traction and RAPS (A / RAPS (B is to be extended on top priority.

IV. In case, Kota (S) has availed start-up power from Ujjain and RP Sagar has been started up separately, then the two supplies are to be synchronized at Kota (S) / R.P. Sagar for stability and then the supply be extended further to other stations.

V. In case Ramgarh GT's are self started the supply from BBMB shall be properly synchronized at Ratangarh or Bikaner before further extending.

5.3. Synchronization

Rajasthan Sub-System is to be synchronized with rest of the grid at the following possible connections:

i) 400 kV Hissar-Bassi at Hissar / Bassi.

ii) 400 kV Agra-Bassi at Bassi/Agra

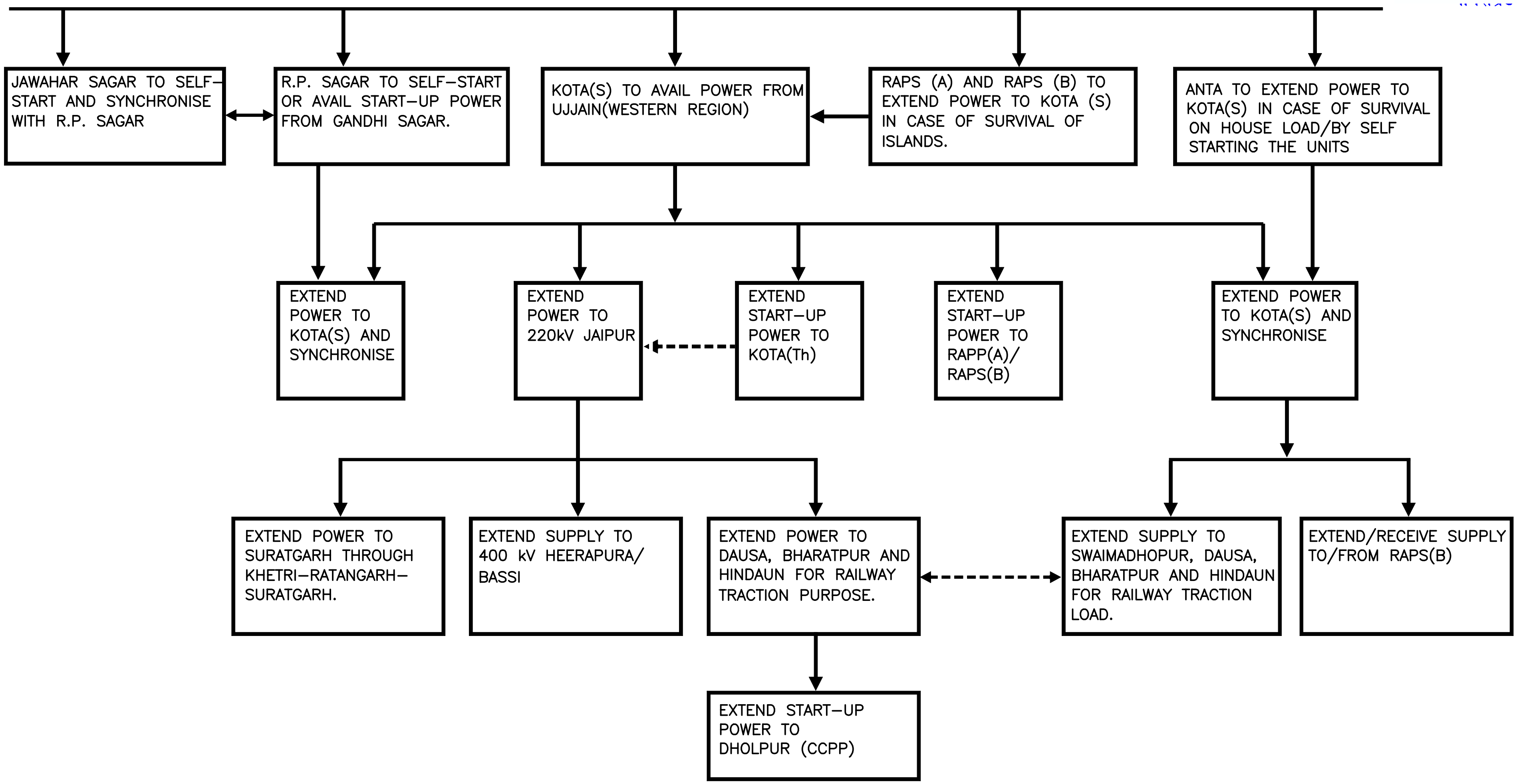
iii) 400 kV Ballabgarh-Bhiwadi at Ballabgarh/Bhiwadi

5.4. Start-Up Stages And Sequence

I. For different Restoration Stages in Rajasthan Subsystem, refer **Exhibit- 5A.**

II. For detailed Start-up Sequence in Rajasthan Subsystem refer, **Exibit-5B**.

RAJASTHAN SUBSYSTEM : RESTORATION STAGES



NOTE:–

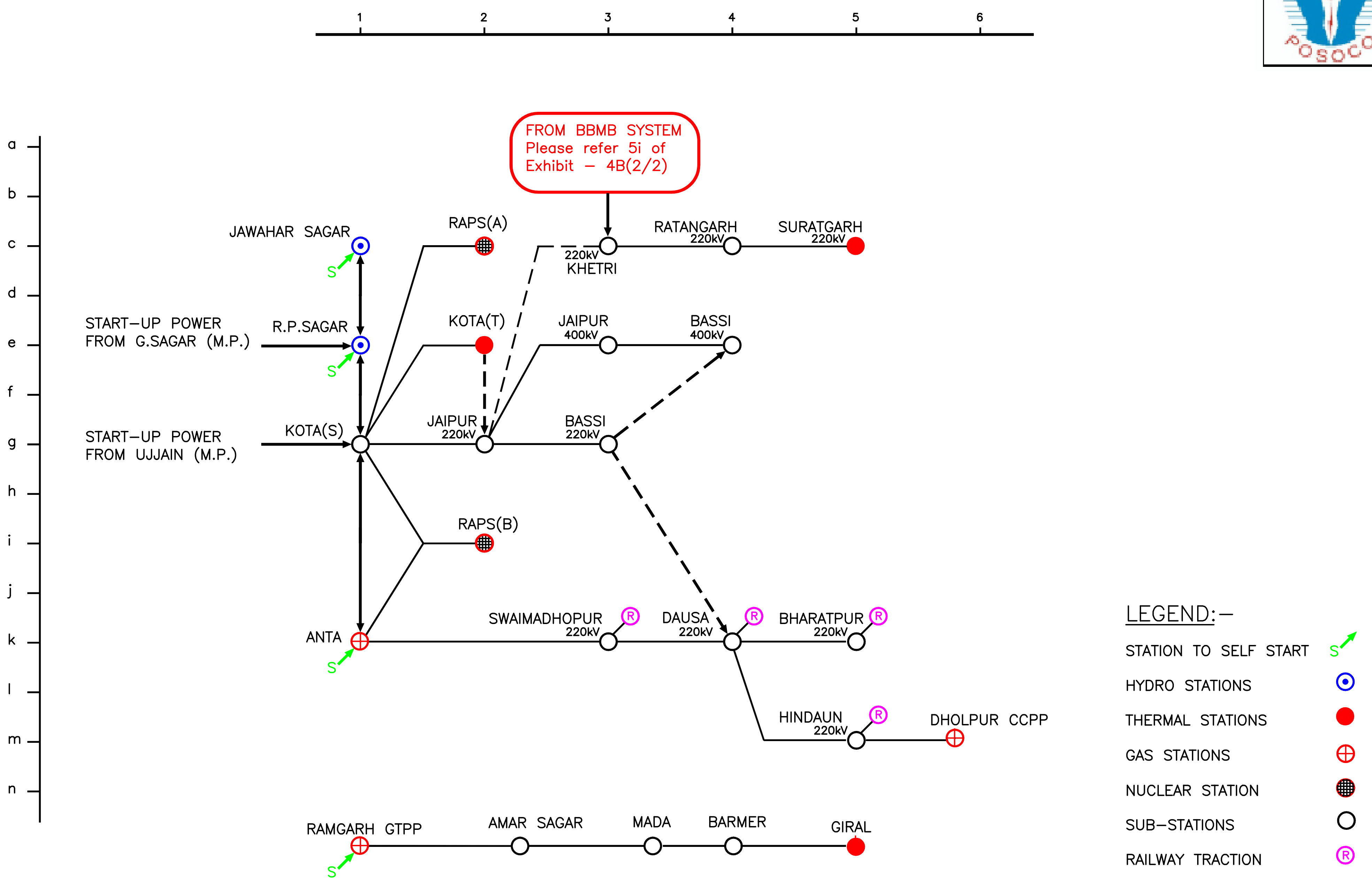
1 KOTA(S) SHOULD AVAIL SUPPLY FROM UJJAIN AND IN THE EVENT OF ANY DIFFICULTY IN GETTING SUPPLY FROM UJJAIN, IT SHALL AVAIL SUPPLY FROM R.P. SAGAR.

2 IF R.P. SAGAR IS NOT ABLE TO SELF START OR IS UNABLE TO AVAIL START–UP POWER FROM GANDHI SAGAR THEN SUPPLY SHALL BE TAKEN FROM KOTA(S).

DRN.BY *Ramjit* *REV.-* JANUARY 2012

EXHIBIT–5B

RAJASTHAN SUBSYSTEM : START–UP SEQUENCE



DRN.BY Ramjit

JANUARY 2012

Chapter-6: Restoration Of Western U.P. /Uttarakhand Subsystem

6.1. Subsystem Overview

Western UP or Uttarakhand sub-system is connected with North - Central sub-system and Eastern UP sub-system. It is also connected with Nepal on its eastern side at Tanakpur. Detailed description of this sub-system restoration is given in this chapter

6.1.1. Important Connecting Links with other Subsystems:

a. With North-Central (NC) Subsystem

1. 400 kV Dadri - Muradnagar
2. 400 kV Agra (UP)-Muradnagar
3. 400 kV Meerut – Mandaula
4. 400kV Meerut-Kaithal

b. With Eastern U.P. Subsystem

1. 400 kV Lucknow(U.P)-Bareilley(P.G)
2. 400kV Lucknow(P.G)-Bareilley(P.G) D/C
3. 400 kV Panki – Muradnagar
4. 400 kV Unnao-Bareilly D/C
5. 220kV Shahjahanpur-Bareilley
6. 220kV Mainpuri(P.G)-Harduaganj
7. 220kV Mainpuri(U.P)-Harduaganj
8. 220kV Agra-Hathras
9. 220kV Agra-Harduaganj

6.1.2. Major Generating Stations

a) Thermal: Harduaganj
b) Hydro: C hibro, Khodri, Dhakarani, Dhalipur, Kulhal, Khara, Chilla, Maneri Bhali, Ramganga, Tanakpur, Dhauli Ganga, Tehri, Vishnu Prayag, Maneri bhali-II(Dharasu)
c) Gas: Nil
d) Nuclear: Narora

6.1.3. Sources of Start-up power

a) Tehri – Self Start: 150 MW
b) Chibro - Self start: 100 MW
c) Ramganga -Self start: 100 MW
d) Remaining hydro stations: 100 MW

Total: 450 MW

6.1.4. Requirement of Start -up power:

a) Start-up Power to Narora:	40 MW
b) Other Essential loads:	410 MW
Total:	**450 MW**

6.1.5. System Synchronization:

For synchronization of Western U.P./Uttarakhand Subsystem with other Subsystems, the preferable system synchronizing sequence shall be as follows:

a. Initially the Eastern U.P. Sub-system and North-Central (NC) Subsystem shall be synchronized.

b. Subsequently, the combined North-Central (NC) Subsystem + Eastern U.P. Subsystem shall be synchronized with the Rajasthan Subsystem.

c. Finally, the combined Eastern U.P. Subsystem + North-Central (NC) Subsystem + Rajasthan Subsystem shall be s ynchronized with Western U.P. Subsystem at the following possible connections:

i. 400 kV Dadri-Muradnagar at Dadri/Muradnagar
ii. 400 kV Agra (UP)-Muradnagar at Agra (UP)/Muradnagar
iii. 400 kV Panki-Muradnagar at Panki/Muradnagar
iv. 400 kV Lucknow-Moradabad at Lucknow/Moradabad

The above synchronizing sequence is indicative only and has been planned on the basis of experience derived from the past incidences. However, in real time conditions adopting a particular sequence for synchronization of different subsystems would depend on the actual situation prevailing at that particular time and the sequence may accordingly be followed /suitably modified.

6.2. Subsystem Restoration Procedure

The Western U.P./Uttarakhand Subsystem shall consist of the following sub-sections:

1) Yamuna Complex - consisting of hydro stations at Chibro, Khodri, Dhakrani, Dhalipur and Kulhal.
2) Khara hydro station
3) Chilla and Maneri Bhali hydro stations
4) Ramganga, Tanakpur and Khatima Hydro Stations
5) Narora Island
6 Vishnu Prayag Hydro Station
7 Tehri Hydro Station
8 Dhauli Ganga Hydro Station

At the time of subsystem built up, the action to be taken at the major generating stations / grid substations is as follows:

6.2.1. Yamuna Complex

i) The generating units of Chibro power house to be self-started and supply is to be extended to Khodri.

ii) The generating units at Khodri to be self started /synchronized with the supply extended from Chibro and the combined supply shall be extended to 220 kV Saharanpur and Rishikesh sub-station.

iii) 220 kV Rishikesh shall extend supply to the 400 kV Muzaffarnagar through 220 kV Roorkee & 220 kV Muzaffarnagar (Nara) for extending reference supply to Vishnu Prayag.

iv) Muzaffarnagar (Nara) shall extend supply to 400 kV Meerut through 220 kV Nara-Meerut line.

v) Dhakrani, Dhalipur & Kulhal hydro stations to start their machines and synchronise with the supply from Khodri/Chibro.

vi) From Khodri and Kulhal supply shall also be extended to Majri (HP) and Giri (HP) respectively for extending reference to the hydro stations of H.P. and to meet emergency load.

vii) 220 kV Saharanpur shall extend supply to the 220 kV Muradnagar through Shamli and Baraut.

viii) Muradnagar shall also extend supply to 220 kV Noida through Sahibabad to meet the emergency loads.

ix) 400 kV Bus of Muradnagar sub-station shall be charged through 220 kV / 400 kV ICTs at Muradnagar for extension of supply up to Moradabad and synchronization with other Subsystems.

Caution

Having the supply extended from Khodri and Kulhal generating stations, HPSEB shall use the supply only for extending reference to hydro stations and emergency loads (Initially to be restricted to around 20 MW maximum)

6.2.2. Khara Hydro Station:

i) The units at Khara shall be self-started / synchronized with the supply extended from stations in Yamuna complex viz. Chibro Khodri, Dhakrani, Dhalipur and Kulhal.

ii) In the event of any problem in self-starting of the units at Khara the start-up power at Khara shall be availed from Yamuna Complex.

iii) Alternatively in the event of any problem in self-starting of the units at Yamuna Complex the start-up power shall be extended from Khara.

iv) In the event of start up of Yamuna Complex and Khara separately, the two supplies shall be synchronized at the earliest opportunity.

6.2.3. Chilla And Maneri Bhali Hydro Stations

i) The hydro station at Chilla and Maneri Bhali shall be self started and synchronized with the supply extended from Yamuna Complex through Rishikesh.

ii) In the event of any difficulty in self-starting of above units start up power shall be availed through Rishikesh.

iii) From Rishikesh the supply shall be further extended to 220 kV Muradnagar through Muzaffarnagar and Meerut.

iv) From 220 kV Muradnagar supply shall be extended to Muradnagar 400 kV for further interconnections.

v) After the supply at Muradnagar 400 kV is stabilized, it shall be extended to Moradabad 400 kV.

6.2.4. Ramganga, Tanakpur and Khatima Hydro Stations

i) The generating units at Ramganga shall be self-started and the supply shall be extended up to Moradabad through Nehtaur or Kashipur.

ii) The generating units of Tanakpur shall be self started and the supply shall be extended up to Moradabad through Bareilly and the two supplies at Moradabad (one from Ramganga and other from Tanakpur) would be synchronized

iii) In the event of any problem in self-starting the units at Tanakpur and/or charging the line up to Moradabad, the reference would be extended from Moradabad up to Tanakpur through Bareilly and thereafter the generating units at Tanakpur would be started and synchronized.

iv) Similar approach (as stated at iii) above) would be taken in the event of any problem in start-up of units at Ramganga.

v) The hydro Units of Khatima shall be self started and synchronized with the supply extended from Bareilly through Dhona. In the event of non-starting of the units at Khatima start-up power shall be availed from

220 kV Bareilly.

6.2.5. Vishnu Prayag Hydro Stations

i) The units at Vishnu Prayag shall be self-started & synchronized with the supply extended from Muzaffarnagar through 400 kV Muzaffarnagar-Vishnu Prayag.

ii) In the event of any problem in self-starting of the units at Vishnu Prayag the start-up power shall be availed from Yamuna Complex through 400 kV Muzaffarnagar-Vishnu Prayag.

iii) Power shall be ex tended to Vishnu Prayag from Muzaffarnagar through either of the two circuits keeping line reactors (50 MVAR each) in service at both the ends. On energization of line-1 or line-2, Vishnupryag will energize its either Bus-I or Bus-II of GIS. Then units are synchronized at unit breaker level with the grid.

Caution: For the startup, simultaneous energization of both c circuits should be avoided in view of high voltage at Vishnu Prayag end.

6.2.6. Tehri Hydro Station

i) The units at Tehri shall be self-started / synchronized with the supply extended from Meerut through 400 kV Meerut-Koteshwar pooling-Tehri Line.

ii) In the event of any problem in self-starting of the units at Tehri the start-up power shall be availed from Yamuna Complex through 400 kV Meerut-Koteshwar pooling-Tehri.

iii) Extend supply to Narora atomic through 400 kV Tehri-Koteshwar pooling-Meerut - 220 kV Meerut-Simbholi (directly or via ShatabdiNagar)-Narora.

6.2.7. Koteshwar Hydro Station

i) The units at Koteshwar shall be self-started / synchronized with the supply extended from Meerut through 400 kV Meerut-Koteshwar pooling-Koteshwar Line.

ii) In the event of any problem in self-starting of the units at Koteshwarthe start-up power shall be availed from Tehri complex 400 kV Meerut-Koteshwar pooling-Tehri.

iii) Extend supply to Narora atomic through 400 kV Koteshwar-Koteshwar pooling-Meerut - 220 kV Meerut-Simbholi (directly or via ShatabdiNagar)-Narora.

6.2.8. Dhauli Ganga Hydro Stations

i) The units at Dhauli Ganga shall be self-started / synchronized with the supply extended from Bareilly through 400 kV Bareilly - Dhauli Ganga.

ii) In the event of any problem in self-starting of the units at Dhauli Ganga the start-up power shall be av ailed from Ramganga, Tanakpur & Khatima Complex through 400 kV Bareilly Dhauli Ganga.

iii) If supply to Rosa TPS is not available by now this supply can be extended to Rosa TPS through Bareilley-Shahjahanpur-Rosa Circuit.

6.2.9. Narora Island

Case a) Narora Islands and Survives

iv) In case of survival of Narora Island, the following actions shall be taken in the descending order of priority in order to stabilize the Narora island.

Priority-1: The units at Ramganga shall be self-started and the supply shall be extended up to Narora through Ramganga – Nehtaur - Moradabad or Ramganga-Kashipur-Moradabad for synchronization at Narora.

Priority-2: The units at Tehri shall be self-started and the supply shall be extended up to Narora through 400kV Tehri-Koteshwar pooling-Meerut and 220kV Meerut–Simbholi for synchronization at Narora.

Priority-3: The hydro units at Yamuna complex (Chibro, Khodri, Dhakrani, Dhalipur and Kulhal) shall be self-started and the supply shall be extended up to Muradnagar 220 kV as stated under Para 6.2.1. From Muradnagar the supply shall be ex tended up to Narora through Muradnagar-Khurja-Harduaganj Narora for synchronization at Narora. In case Narora has islanded with Khurja and Simbholi loads, please ensure that the two supplies do not get mixed up at Khurja.

Priority-4: In case there is in-ordinate delay in the above three operations and by that time the North Central sub-system has been stabilized and supply is available at Agra (new) substation of UPPCL then the supply to Narora is to be extended through Agra (new)-Hathras-Harduaganj-Narora for synchronization at Narora.

Priority-5: Supply for Narora Island from North-Central Subsystem can also be extended through 220 kV Mainpuri-Harduaganj-Narora.

Caution

i) In the event of survival of Narora island, UPPCL has to take necessary steps to extend the stabilized supply from the built up Western UP subsystem to Narora at the earliest. After synchronizing the Western UP Subsystem with Narora, all care is to taken by UPPCL to avoid any sudden variation in the load in the Western U.P. sub-system which may otherwise result in collapse of the sub-system and poisoning out of the nuclear units. Narora would also keep itself in close contact with UPPCL Control Room at Lucknow as well as concerned substation at UPPCL where the connectivity with Narora exists, for coordination in respect of load-generation balance.

ii) Since the extension of supply from the stabilized North-Central Subsystem to Narora being at the farthest end, may take relatively longer time, this arrangement has been shown as the last priority (no.3/4). However, in the event of inordinate delay in extension of supply from Western UP/Uttarakhand subsystem as shown under first two priorities, priority 3/4 would be the only alternative and till such period all care would be taken by UPPCL / Narora to save the Narora island by maintaining load generation balance.

Case b) Non-survival of Narora Island

In case of collapse of Narora Island and tripping of units at Narora following actions shall be taken in the descending order of priority.

Priority-1: The units at Ramganga shall be self-started and the supply shall be extended up to Narora through Ramganga – Nehtaur - Moradabad or Ramganga-Kashipur-Moradabad for synchronization at Narora.

Priority-2: The generating units at Yamuna complex (Chibro, Khodri, Dhakrani, Dhalipur and Kulhal) would self-start and this supply shall be extended to Narora at 220kV through Muradnagar and Khurja.

Priority-3: The start-up supply from Tehri and Yamuna Complex shall be extended up to Narora through 220 kV Meerut-Simbholi (directly or via ShatabdiNagar)-Narora.

Priority-4: In case of inordinate delay in getting the supply from either of the first three priorities, the supply would be extended to Narora at 220 kV from the built up and stabilized North-Central (NC) subsystem through Agra (new) and Harduaganj or alternatively through 220 kV Mainpuri-Harduaganj-Narora.

Priority-5: In case there is inordinate delay in getting the supply from either of the first three priorities and by that time the North-Central Sub-system has been stabilized, then the supply to Narora is to be extended through 400 kV Mandaula-400 kV Meerut-220 kV Simbholi-220 kV Narora.

Caution:

i) In the event of tripping of Narora units, the supply to Narora is to be extended on priority basis.

ii) At all times, load - generation balance is to be maintained in the built up subsystem by bringing the generation / load in a gradual manner and maintaining system parameters in normal range.

6.3. Synchronization

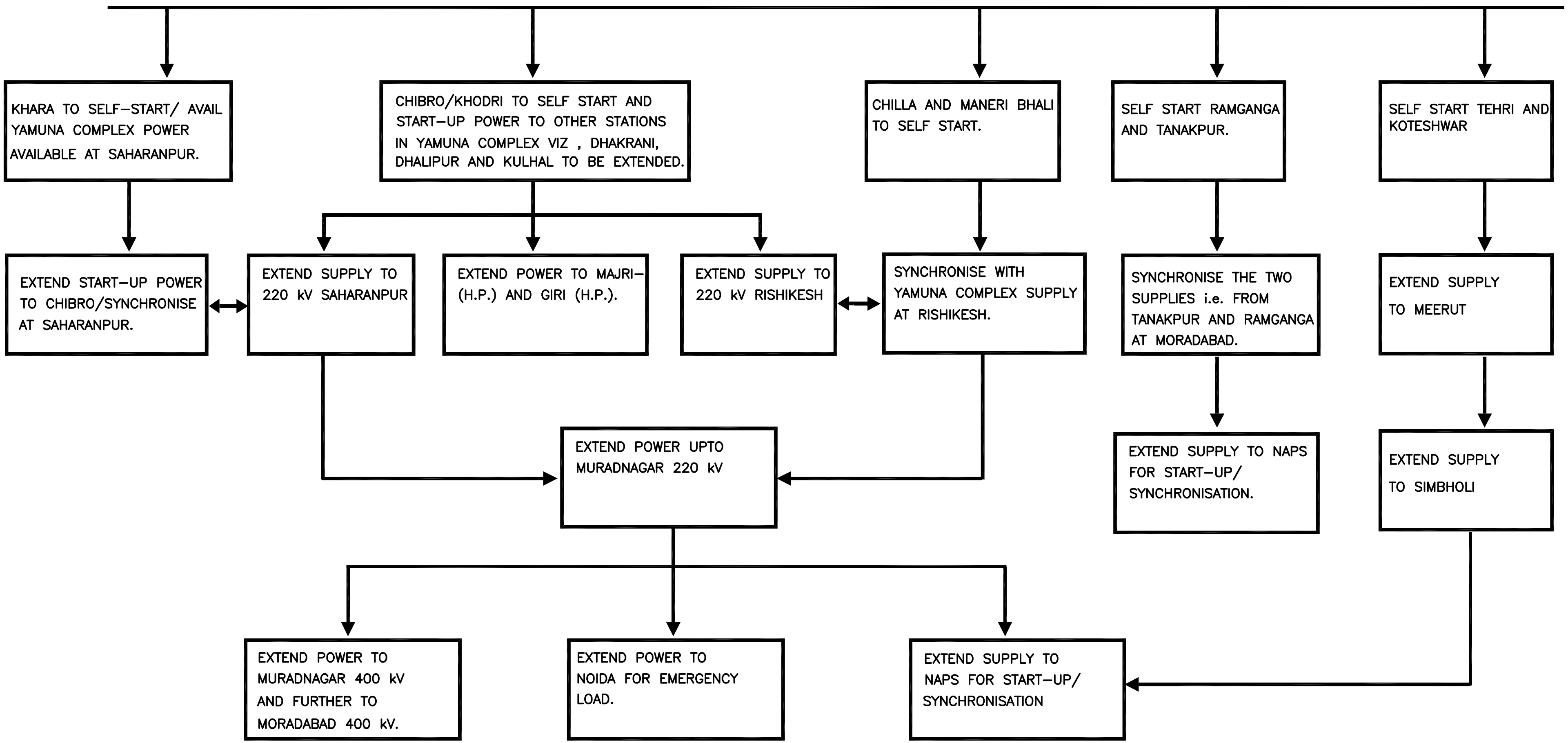
The synchronization of the Western U.P. Subsystem can be carried out with the combined North-Central (NC) + Eastern U.P. + Rajasthan subsystem at the following possible connections:

1. 400 kV Dadri-Muradnagar at Dadri/ Muradnagar
2. 400 kV Agra-Muradnagar at Agra/Muradnagar
3. 400 kV Panki-Muradnagar at Panki/Muradnagar
4. 400 kV Lucknow(U.P)-Bareilley(P.G) at Lucknow/Bareilley
5. 400 kV Lucknow(P.G)-Bareilley(P.G) at Lucknow/Bareilley
6. 400KV Unnao-Bareilley(U.P) at Unnao/ Bareilley(U.P)
7. 400 kV Meerut-Kaithal at Meerut/ Kaithal

6.4. Startup Stages and Sequence:

i) For different Restoration Stages in Western U.P./Uttarakhand Subsystem refer, **Exhibit-6A**
ii) For detailed Start-up Sequence in Western U.P./Uttarakhand Subsystem refer, **Exhibit- 6B**

WESTERN U.P./UTTRANCHAL SUBSYSTEM : RESTORATION STAGES



NOTE:–

1 IF FOR ANY REASON CHIBRO CAN NOT START THEN ANY OTHER POWER STATION IN SUCESSION VIZ KHODRI, DHAKRANI, DHALIPUR AND/OR KULHAL HAS TO START AND EXTEND POWER UPTO MURADNAGAR.

2 IN THE EVENT OF NON START–UP OF ANY POWER HOUSE OF YAMUNA COMPLEX, KHARA SUPPLY AVAILABLE AT SAHARANPUR SHALL BE SENT BACKWARDS TO YAMUNA COMPLEX.

3 IN CASE OF COLLAPSE OF NAPP ISLAND RAMGANGA IS TO SELF START AND EXTEND POWER TO NAPP. IF THERE IS INORDINATE DELAY IN GETTING THE SUPPLY FROM WESTERN U.P. AND AVAILABILITY OF NORTH–CENTRAL SUB SYSTEM SUPPLY AT HARDUAGANJ 220 kV, THEN SUPPLY CAN BE AVAILED BY NAPP FROM HARDUAGANJ IN CO–ORDINATION WITH CLDS LUCKNOW AND NRLDC.

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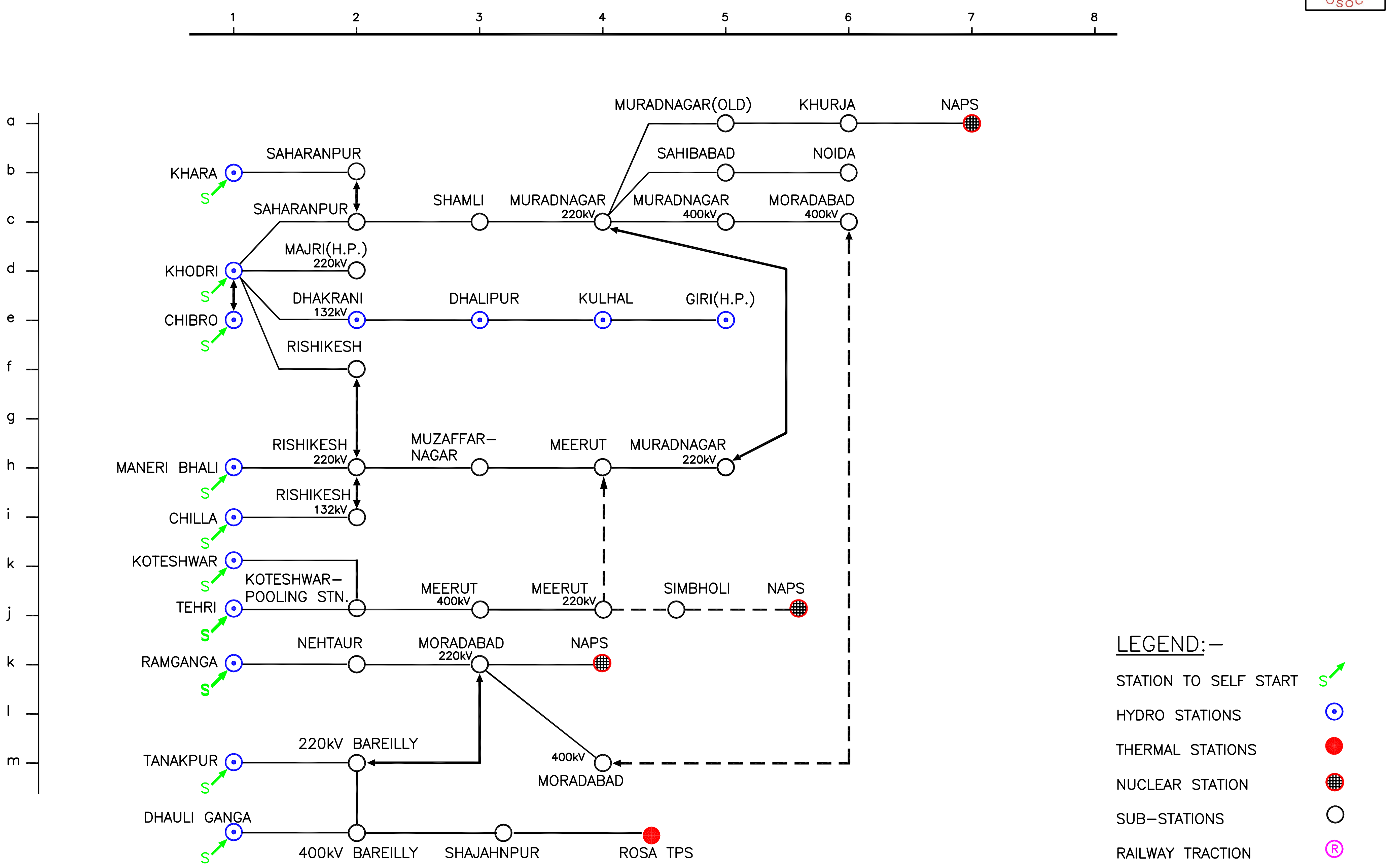
EXHIBIT–6B

WESTERN U.P. SUBSYSTEM : START–UP SEQUENCE



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Chapter-7: Power Supply to Railway Traction

Power Supply to Railway Traction

From the networks of Northern Region, power is fed to the following zones of Railways:

1. Northern Railway (NR): Major trunk routes
    - Delhi-Ring
    - Delhi-Ambala-Saharanpur-Roorkee-Moradabad
    - Kalka -Ambala-Una – Ludhiana -Amritsar
    - Delhi-Ballabgarh
    - Lucknow-Roza
2. North Central Railway (NCR): Major trunk routes
    - Ballabgarh-Mathura
    - Mathura-Agra
    - Kanpur-Lucknow
    - Kanpur-Tundla
    - Tundla-Delhi
    - Mugal Sarai-Allahabad-Kanpur
    - Agra-Bayana
3. West Central Railway (WCR): Major trunk routes
    - Mathura-Kota-Mumbai
4. North Eastern Railway (NER): Track electrification under progress

During system restoration, it is proposed to meet the power requirement of each of the above Railway Zones in the following manner.

7.2. Northern Railway (NR)

7.2.1. Power supply from North-Central (NC) Subsystem:

a) From Delhi system, the following traction load shall be fed:

i) Railway section = Delhi ring
ii) Railway traction/Grid Substation = Chanakya Puri
iii) Max. Railway traction load = 15 MVA
iv) Feeding grid sub-stations=220kV Park street (DTL)

b) From HVPN/Delhi system, the following traction load shall be fed:

i) Railway section = Delhi-Ambala -Saharanpur
ii) Railway traction Substations = Diwana, Taraori, Shahbad-Markanda, Jagadhari.
iii) Max. Railway traction load = 62.5 MVA
iv) Feeding grid sub-stations= 220 kV Narela (NDPL), 220

kV Panipat (HVPN), 400 kV Abdullapur (POWERGRID).

c) From PSEB system the following traction load shall be fed:

i) Railway section = Kalka – Ambala – Una – Ludhiana - Amritsar.
ii) Railway traction Substation = Ghaggar, Rajpura, Kurali, Anandpur - Sahib, Sahnewal, Chiheru & Butari.
iv) Max. Railway traction load = 78.5 MVA
v) Feeding grid sub-stations =220 kV Dera Bassi, 220 kV Rajpura, 220 kV Ropar Grid, 132 kV Anandpur Sahib, 220 kV Laltokalan, 220 kV Jamsher & 220 kV Butari.

d) From BBMB, the following traction load shall be fed:

i) Railway Section = Delhi-Ballabgarh-Palwal
ii) Railway Traction Substation = Ballabgarh
iii) Max. Railway traction load = 33 MVA
iv) Feeding grid sub-stations = 220 kV Ballabgarh

e) From PTCUL, the following traction load shall be fed:

i) Railway Section= Saharanpur-Roorkee-Fazalpur
ii) Railway Traction Sub station= Roorkee
iii) Max Railway Traction load= 8 MVA
iv) Feeding Grid Sub-station= 220 kV Ramnagar.

7.2.2. Power Supply from Eastern UP Sub system:

From Eastern U.P. Subsystem (Built-up by availing start-up power from WR through Vindhyachal AC bypass link) the following traction load of Northern Railway shall be fed:

i) Railway Section = Kanpur-Lucknow, Lucknow-Roza
ii) Railway Traction Substation = Amausi, Umartali
iii) Max. Railway traction load =19.5 MVA
vi) Feeding grid sub-station= 220 kV Sarojini Nagar , 132 kV Sandila

7.2.3. Power Supply from Western UP Sub system:

From western U.P./Uttarakhand Subsystem the following traction load of Northern Railway shall be fed:

i) Railway Section = Roorkee-Fazalpur-Moradabad
ii) Railway Traction Substation = Fazalpur
iii) Max. Railway traction load =3.0 MVA
iv) Feeding grid sub-station=132 kV Nethore

7.3. North Central Railway (NCR)

7.3.1. Power supply from North-Central Subsystem:

a) From BBMB the following traction load of North Central Railway (NCR) shall be fed:

i) Railway section = Ballabgarh -Mathura
ii) Railway traction Substation = Hodal
iii) Max. Railway traction load = 20 MVA
iv) Feeding grid sub-station = 220 kV Ballabgarh

b) From UPPCL the following traction load of North Central Railway (NCR) shall be fed:

i) Railway section = Mathura-Agra
ii) Railway traction Substation = Mathura, Pathauli, Bhandai
iii) Max. Railway traction load = 38 MVA
iv) Feeding grid sub-stations = 220/132 kV Agra (Sikandra)

c) From Auraiya the following traction load of North Central Railway (NCR) shall be fed:

i) Railway section = Kanpur-Tundla
ii) Railway traction Substation = Rura, Phaphund, Bharthna, Etawah, Bhadan, Shikohabad.
iii) Max. Railway traction load = 50 MVA
iv) Feeding grid sub-stations = Auraiya directly feeding 220 kV Phaphund (Railways)

d) From Dadri (gas) the following traction load of North Central Railway (NCR) shall be fed:

i) Railway section = Tundla-Delhi
ii) Railway traction Substation = Mitawali, Hathras, Mehrawal, Khurja, Dankaur, & Sahibabad.
iii) Max. Railway traction load = 50 MVA
iv) Feeding grid sub-stations = 220 kV Dadri (Gas) directly feeding 220 kV Dankaur (Railway)

7.3.2. Power supply from Eastern UP Subsystem

a) From Eastern U.P. Subsystem (Built-up by availing start-up power from ER through Sasaram AC bypass link) the following traction load shall be fed:

i) Railway section = Mugalsarai-Allahabad-Kanpur
ii) Railway traction Substation = Jeonathpur, Chunar, Mirzapur, Jigna, Bheerpur, Naini, Manauri, Sirathu, Rasulabad.

iii) Max. Railway traction load = 80MVA
iv) Feeding grid sub-stations = 220 kV Sahupuri, 220 kV Obra, 220 kV Allahabad (RR), 220 kV Fatehpur (All belongs to UPPCL)

b) From Eastern U.P. Subsystem (Built-up by availing start-up power from WR through Vindhyachal AC bypass link) the following traction load shall be fed:

i) Railway section = Allahabad-Kanpur
ii) Railway traction Substation = Malwan, Sarsaul, Panki.
iii) Max. Railway traction load = 75 MVA
iv) Feeding grid sub-stations= 220 kV Naubasta (UPPCL), 220kV Panki (UPPCL)

7.3.3. Power supply from Rajasthan Subsystem:

From Rajasthan Subsystem the following traction load of North Central Railway shall be fed:

i) Railway section = Agra-Bayana
ii) Railway traction Substation = Bayana
ii) Max. Railway traction load = 6 MVA
iii) Feeding grid sub-stations = 220 kV Dausa (RVPNL), 220 kV Bharatpur (RVPNL).

7.3.4. Power supply from Madhya Pradesh:

The North Central Railway to feed traction loads from Hetampur up-to Bina (MP) over their own network including the load of Lalitpur (UP).

7.4. West Central Railway (WCR)

7.4.1. Power supply from Rajasthan Subsystem:

From Rajasthan Subsystem the following traction load of West Central Railway shall be fed:

i) Railway section = Mathura-Kota-Mumbai
ii) Railway Traction Substation = Bharatpur, Bayana, Hindun city, Gangapur city, Sawai-Madhopur, Lakheri, Gurla & Ramganj mandi.
iii) Max. Railway traction load = 70 MVA
iv) Feeding grid sub-stations =220 kV Bharatpur, 220 kV Hindun, 220 kV Sawai-Madhopur, 220 kV Kota (S), 220 kV Morak.

7.5. North Eastern Railway (NER)

The electrification work of tracks in North-Eastern Railway (NER) of Northern Region is under progress.

7.6. Delhi Metro

7.6.1. Power supply from North-Central Subsystem:

Power Supply to Delhi metro can be extended from following 220 kV Stations of DTL:

i. 220 kV Kashmiri gate-
220 kV Double Circuit to Metro station.

ii. 220 kV Papankalan-I (Dwarka-I)-
66 kV Double Circuit to Metro station.

iii. 220 kV Papankalan-II (Dwarka-II)-
66 kV Double Circuit to Metro station

iv. 220 kV Rohini
66 kV Double Circuit to Metro station

v.220 kV IP Extension (GT)
66 kV Single Circuit to Metro station

Caution

In the event of black start, initially the different subsystems shall be of small size and the running generating units particularly the gas turbines shall have a limitation in regard to the ramp up rates and negative sequence current. The negative sequence current is caused primarily due to unbalance load in the system. Therefore, as soon as the power is made available for the purpose of traction, it would be ensured by Railways that the load shall be kept balanced and stable and the movements of trains in different sections would be coordinated and controlled for avoiding sudden jerks/ramp ups on the system.

7.7. Traction Sub-Stations Schematic Diagrams

Refer Exhibit-7A & Exhibit-7B for Traction Supply to Northern Railway, North Central Railway, West Central Railway & North Eastern Railway.

EXHIBIT – 7A

POWER SUPPLY TO NORTHERN RAILWAY TRACTION

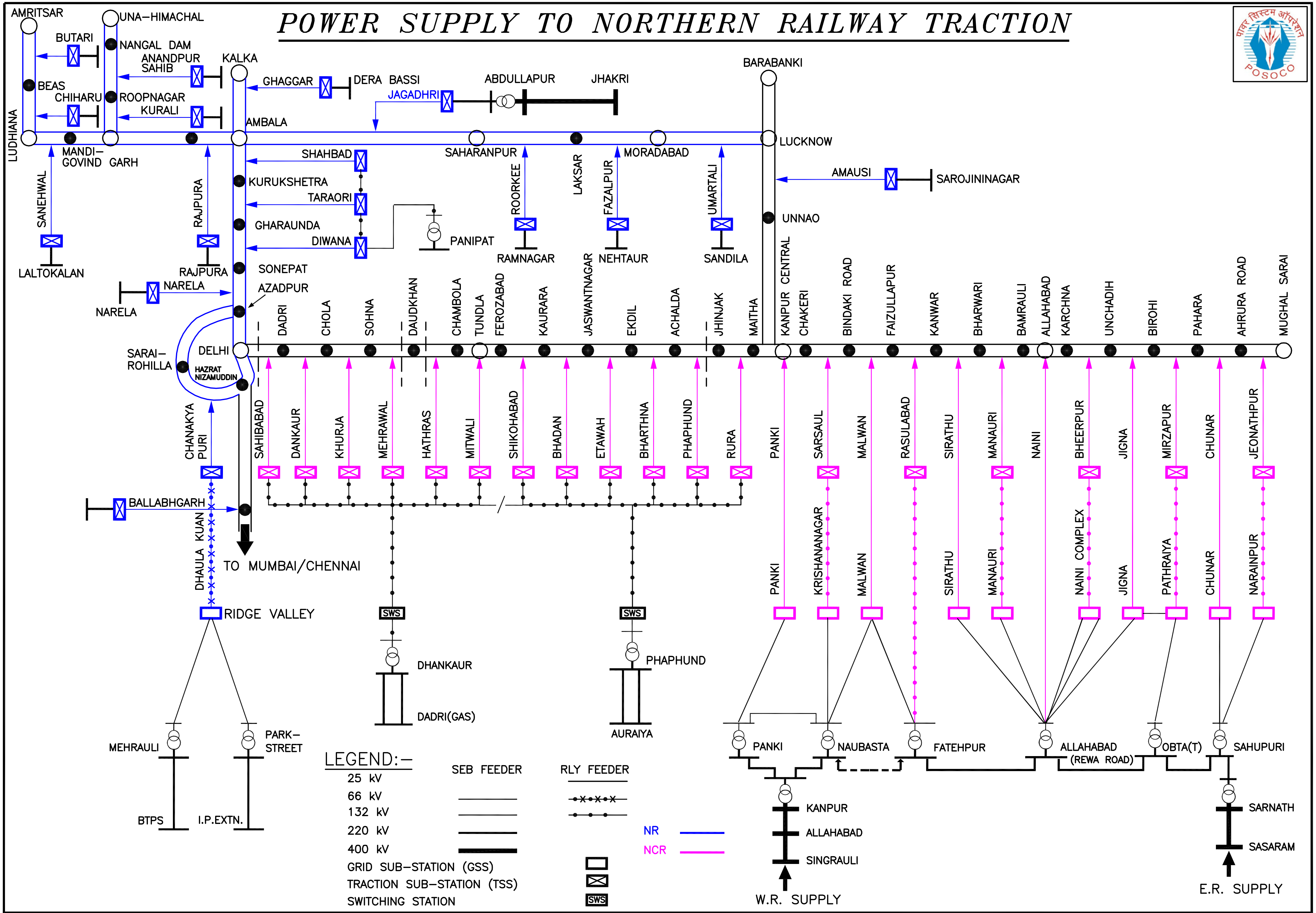

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EXHIBIT – 7B

POWER SUPPLY TO CENTRAL AND WESTERN RAILWAYS TRACTION

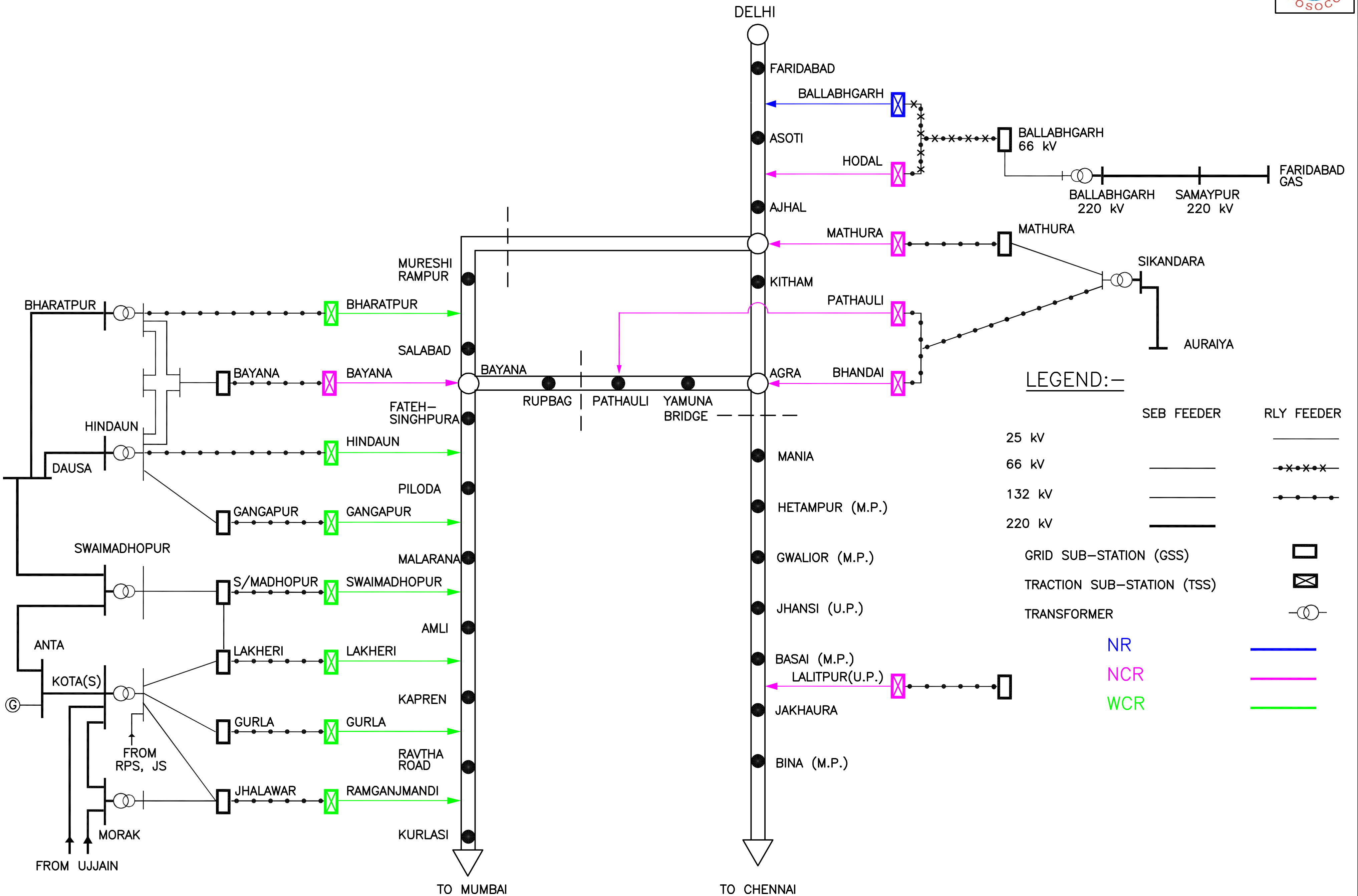

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Exhibit-7C: List of Grid Sub-Station Feeding Railway Traction.

Sl. No.	Control Area	Important 400/220/132 kV Station	Railway Route Affected
1	Delhi (DTL)	220 kV Park Street (DTL)& 220 kV Mehrauli (DTL)	Delhi Ring
2	Haryana (HVPN)	220 kV Panipat (HVPN)	Ambala-Saharanpur
3	Punjab (PSEB)	220 kV Dera-Bassi, 220 kV Rajpura, 220 kV Ropar, 220kV Laltokalan, 220 kV Jamsher, 220 kV Butari, 132 kV Anandpur Sahib	Ambala-Una-Amritsar
4	Chandigarh (BBMB)	220 kV Ballabgarh	Delhi-Ballabgarh-Mathura
5	Uttarakhand (PTCUL)	220 kV Ramnagar	Saharanpur-Roorkee-Fazalpur
6	Uttar Pradesh	220 kV Sarojini Nagar	Kanpur-Lucknow
		220 kV Agra (Sikandara)	Mathura-Agra
		220 kV Phaphund (from 220 kV Auraiya)	Kanpur-Tundla
		220 kV Sahupuri, 220kV Obra (T), 220 kV Allahabad (RR), 220 kV Fatehpur, 220kV Naubasta, 220 kV Panki	Mugal Sarai-Allahabad-Kanpur
		132 kV Lalitpur	Agra-Bina (MP)
		132 kV Nethaur	Roorkee-Fazalpur-Moradabad
		132 kV Sandila	Lucknow-Rosa
7	Rajasthan	220kV Dausa, 220 kV Bharatpur	Agra-Bayana-Kota
			Mathura-Bayana-Kota
		220 kV Hindun, 220 kV Sawai-Madhopur, 220 kV Kota (S), 220 kV Modak	Mathura-Kota-Mumbai
8	Central Sector	400kV Abdullapur	Delhi-Ambala-Saharanpur
		220 kV Dadri (Gas) Feeding Dankaur	Tundla-Delhi
		220 kV Auraiya to 220 kV Phaphund	Kanpur-Tundla

Chapter-8: Operation Of 400 kV Vindhyachal A.C. By-Pass Link

8.1. Closing Of Vindhyachal A.C. By-Pass Link

In the event of total black out in the Northern Region (NR), start-up power would be ob tained from the Western Region (WR) on Vindhyachal A.C. by-pass ink. Since this link connects the two regions, due care is to be taken while carrying out its operation for connecting the two regions. The schematic diagram depicting the set-up of 400 kV Vindhyachal A.C. by-pass link is shown at Exhibit 8A and the sequence of operation to be carried out at Singrauli and Vindhyachal in order to extend the WR power to NR is as stated below:

8.1.1. Singrauli

i) In the event of total black out in the region, Singrauli shall open breakers for all of its 400 kV Ckt. from Singrauli, except for 400 kV Singrauli-Vindhyachal circuit. In case the breaker of 400 kV Singrauli-Vindhyachal also gets opened then Singrauli shall close it at its end for receiving the supply from Vindhyachal.

ii) Singrauli shall convey to Vindhyachal Back-to-Back station its readiness to receive power from Western Region through the A.C. By-pass link.

iii) Singrauli shall simultaneously inform NRLDC Control Room about the request made by it to Vindhyachal Back -to- Back Station for import of start-up power from Western Region.

8.1.2. Vindhyachal HVDC (Back To Back)

Following actions shall be taken by Vindhyachal Back to Back station:

i) Vindhyachal Back-to-Back station shall initiate action to extend start-up power to Singrauli through the AC By-pass link as soon as it gathers that there is total loss of supply at 400 kV Singrauli as well as at 400 kV Kanpur sub-stations.

ii) Ensure that breakers AWL3-Q, AWL4-Q and A WL5-Q controlling Singrauli and Kanpur lines are open.

iii) Isolate HVDC Block-1 and Block-2 by ensuring that breaker Nos. B1Q11-Q, B1Q21-Q, B2Q11-Q and B2Q21-Q are in open condition.

iv) Ensure that West Bus 1B is in energized condition. (The continuity of the supply from the Western grid to the Vindhyachal West Bus is to be maintained by keeping the breaker AWL1-Q and / or AWL2-Q in closed conditions)

v) Close isolators D-11 and D-21 to close A.C. By-pass link and thereby charge North BUS 1A.

(For carrying out the actions detailed at (step i to step v) above, no code would be required by Vindhyachal from NRLDC/ WRLDC)

vi) Close breaker AWL3-Q controlling Singrauli line after getting clearance from Singrauli STPS. (The closing of the 400 kV Vindhyachal-Singrauli circuit breaker at Vindhyachal end (AWL3-Q) would result into extension of WR power up t o Singrauli STPP)

8.2. Opening Of Vindhyachal A.C. By-Pass Link

Once the Eastern U.P. subsystem is stabilized and ad equately strengthened, it shall be disconnected from the Western Regional Grid by opening the 400 kV Vindhyachal A.C. By Pass link. Following steps shall be followed in opening of this link.

8.2.1. Vindhyachal HVDC (Back-to-Back)

Initiate the disconnection of NR from WR as soon as clearance is received from NRLDC for disconnection of the link by taking following actions.

i) Open breaker AWL3-Q connecting 400 kV Singrauli-Vindhyachal circuit to Bus 1A. [Just before opening of the breaker, the power flow on the link is to be brought in almost floating condition as per details given under Para 2.4.2 iv)

ii) Open isolators D 11 and D21 to open A.C. By-pass link.

iii) Check that Bus 1A has been deenergised.

iv) Close breaker AWL3-Q connecting 400 kV Singrauli-Vindhyachal circuit to Bus 1A.

v) Start one block of HVDC Back to Back station by closing required devices and r egulate power flow between Western Region and N orthern Region as per instruction of NRLDC and WRLDC. This may be followed by closing of the second block.

.

Note: In the event of total collapse in Northern Region, as per the standing Arrangement to start with 100 MW power shall be made available from Western Region to Northern Region without any formal exchange of codes between Northern Region and Western Region. Therefore, for initial start up and extending the power from WR to NR, Vindhyachal would not require for formal approval from WRLDC (WRLDC is to be informed by Vindhyachal about above action immediately after the transfer of power).

Caution

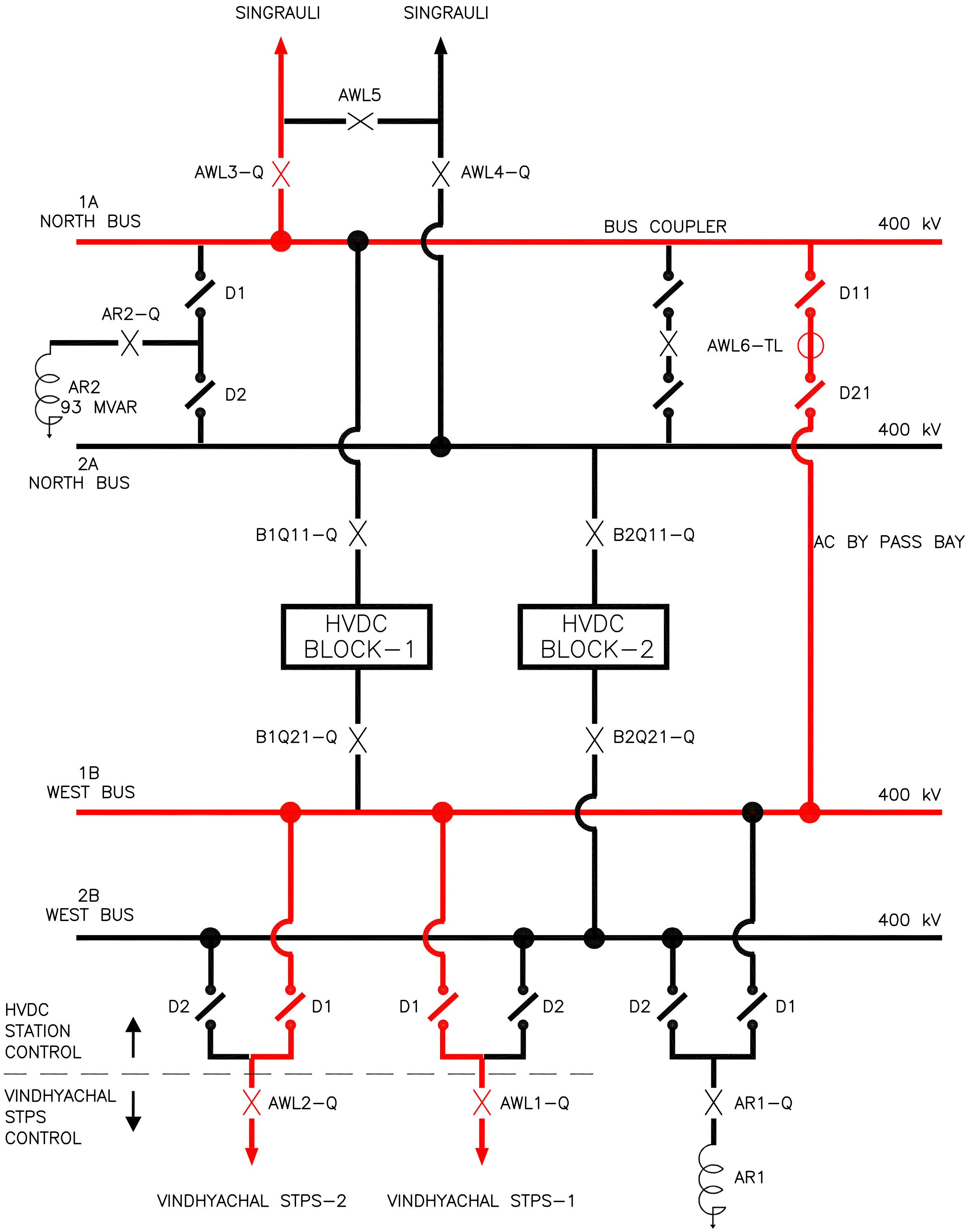
i) Under the situations as explained at above, it would be endeavored by NR to limit the flow on A.C. by pass link in the range of about 100 MW and any additional supply from WR shall be availed in consultation with WRLDC.

ii) Since the initial time taken for extending the start-up power from Western Region to Northern Region shall be vital for normalization of the grid, the operations for closing of A.C. By-pass link should be done in quickest possible manner.

iii) During the initial build-up of Eastern U.P. Subsystem, at the time of charging of 400 kV Singrauli-Allahabad-Kanpur circuit, the voltage at the Vindhyachal 400 kV bus be maintained in the range of around 390 kV by operating the bus reactors AR2 (breaker AR2-Q) and AR1 (breaker AR1-Q)

iv) After disconnection of WR from the built-up Eastern U.P. Subsystem, the Vindhyachal HVDC Back -to- Back Block is to be brought back expeditiously so that asynchronous power flow between WR and NR may be started.

VINDHYACHAL HVDC BACK TO BACK STATION



DRN.BY Ramjit | *REV.–1* | *JANUARY, 2012*

Chapter-9: Operation of 400 kV Sasaram A.C. By-Pass Link

Sasaram HVDC (Back to Back Station) is operating in AC bypass mode i.e. synchronously connected with ER since 1st Dec 2008 in trial mode for finally shifting the HVDC back to back station at some other location. However incase of HVDC back to back operation following steps should be followed during disturbance.

9.1. Closing Of Sasaram A.C. By-Pass Link

In the event of total black out in the Northern Region (NR), start-up power would be obtained from the Eastern Region (ER) on Sasaram A.C. By-pass link. Since this link connects the two regions, due care is to be taken while carrying out its operation for connecting the two regions. The schematic diagram depicting the set-up of 400 kV Sasaram A.C. By-pass link is shown at Exhibit 9A and the sequence of operation to be carried out at Sasaram and Sarnath in order to extend the ER power to NR is as stated below:

9.1.1. Sarnath

i) In the event of total black out in the region, Sarnath shall open breakers for all of its 400 kV circuits from Sarnath, except for 400 kV Sarnath - Sasaram circuit. In case the breaker of 400 kV Sarnath-Sasaram also gets opened then Sarnath shall close it at its end for receiving the supply from Sasaram.

ii) Sarnath shall convey to Sasaram Back-to-Back station its readiness to receive power from Eastern Region through the A.C. By-pass link.

iii) Sarnath shall simultaneously inform CLDS, LUCKNOW / NRLDC, DELHI about the request made by it to Sasaram Back -to- Back Station for import of start-up power from Eastern Region.

9.1.2. Sasaram HVDC (Back to Back)

Following actions shall be taken by Sasaram Back to Back station:

i) Sasaram Back-to-Back station shall initiate action to extend start-up power to Sarnath through the AC By-pass link as soon as it gathers that there is total loss of supply at 400 kV Sarnath, 400 kV Allahabad and other neighboring stations.

ii) Isolate HVDC Back-to-Back Block by ensuring that breaker Nos. Q50 and Q51 of Dia CWD50 & CWD10 are in open condition.

iv) Ensure that Bus II of Eastern side is in energized condition. (The continuity of the supply from the Eastern grid to the Sasaram East Bus is to be maintained by keeping the breaker Q50 of CWD70 or / and

CWD80 in closed conditions)

v) Close isolators Q20 and Q21 of CWD110 and breaker Q52 of CWD50 and CWD10 to close A.C. By-pass link and thereby charge North BUS II.

Note: For carrying out the actions detailed at step i) to step iv) above, no code would be required by Sasaram from NRLDC/ ERLDC.

vi) Close breaker Q52 of CWD30 controlling Sarnath line after getting clearance from Sarnath. {The closing of the 400 kV Sasaram- Sarnath circuit breaker at Sasaram end (Q52 of CWD30) would result into extension of ER power up to Sarnath}

9.2. Opening Of Sasaram A.C. By-Pass Link

Once the Eastern U.P. subsystem is stabilized and adequately strengthened, it shall be disconnected from the ER Grid by opening the 400 kV Sasaram A.C. By Pass link. Following procedure shall be adopted in opening of this link.

9.2.1. Sasaram HVDC (Back-to-Back)

Initiate the disconnection of NR from ER as soon as clearance is received from NRLDC for disconnection of the link by taking following actions.

i) Open breaker Q52 of CWD10 and CWD50.

ii) Open isolators Q20 and Q21 of CWD110 to open A.C. By-pass link.

iii) Start HVDC Back to Back Block and close required Isolators and Breakers and regulate power flow between Eastern Region and Northern Region as per instruction of NRLDC and ERLDC.

Note: In the event of total collapse in Northern Region, as per the standing arrangement to start with 100 MW power shall be made available from Eastern Region to Northern Region without any formal exchange of codes between Northern Region and Eastern Region. Therefore, for initial start up and extending the power from ER to NR, Sasaram would not require for formal approval from ERLDC (ERLDC is to be informed by Sasaram about above action immediately after the transfer of power).

Caution

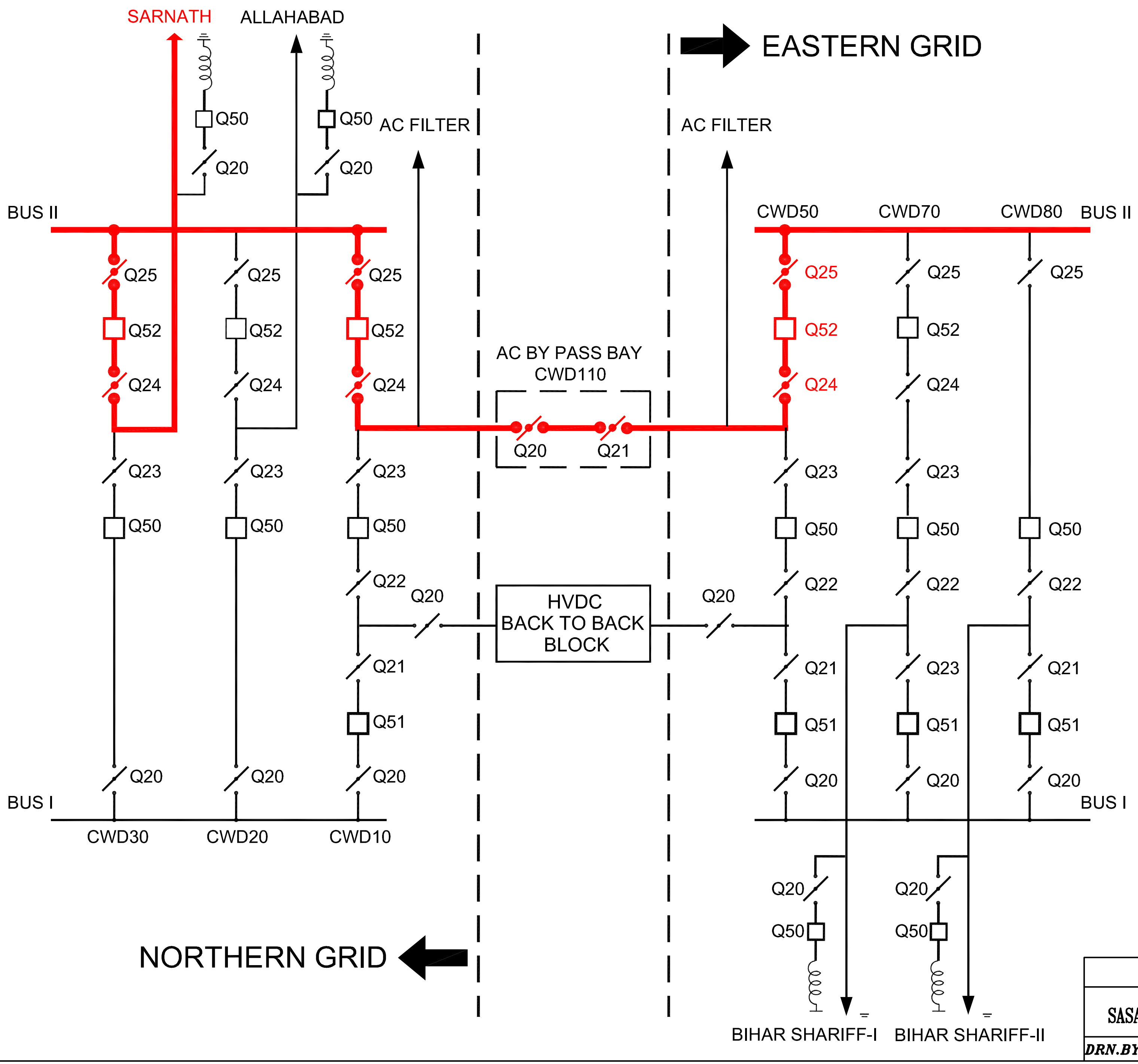
1. Under the situations as explained at i) above, it would be endeavored by NR to limit the flow on A.C. by pass link in the range of about 100 MW and any additional supply from ER shall be availed in consultation with ERLDC.

2. At the time of joining of ER and WR through NR system by charging of 400 kV Sarnath-Allahabad or 400 kV Sarnath-Anpara line, the voltage at the Sasaram 400 kV bus be maintained in the range of around 390 kV by

operating the reactors available at Sasaram/Sarnath

3. After disconnection of ER from the built-up Eastern U.P. Subsystem, the Sasaram HVDC Back-to-Back Block is to be brought back expeditiously so that asynchronous power flow between ER and N R may be s tarted.

SASARAM HVDC BACK TO BACK LINK



NRLDC/POWERGRID		
SASARAM HVDC BACK TO BACK LINK		
DRN.BY Ramjit	REV.-1	JANUARY,2012

Chapter-10: Mock Black Start Exercise

10.1 Chamera-1 HEP Black Start Exercise

10.1.1. Procedure

In order to facilitate the mock black start exercise of Chamera-1 Power house following switching operation is being suggested at 400 kV Jallandhar (POWERGRID), Chamera-I and 220 k V Kotla jangan (PSTCL). During this exercise the supply at 220 kV Kotla jangan(PSTCL) will be affected.

The following preliminary preparations are to be done pr ior to the start of mock exercise i.e., before 10:30 A.M.

1. **Preparation**

   Chamera-1 HEP

   a. Check the preparedness to start one hydro unit using auxiliary supply from the DG set.
   b. Check the possibility to charge a dead 400 KV bus with the black start unit. Interlocks, if any, in the SCADA system might need to be modified in case it inhibits this activity.
   c. Check the necessary settings to smoothly vary the excitation of the black-start unit over the entire range of the generator capability curve so that the 400 KV bus voltages can be smoothly varied.
   d. Settings of the low forward power relay/reverse power relay installed on the generating units and manufacturer's recommendations for this relay settings, if any, during black-start process.
   e. Ability to vary the governor droop setting so as to accommodate block load additions without any problem.
   f. Ability to vary the frequency of the islanded system over a large range from 48.5 Hz- 50.5 Hz.
   g. The check synchronizing relay settings at Chamera-1 HEP available for generating units, lines and 400 kV bus coupler.
   h. Experienced manpower to be deputed for carrying out exercise.

   400/220kV Jallandhar (PG) Substation

   a. Checking the healthiness of synchronizing trolley at 400kV Jallandhar Substation.
   b. Checking the healthiness of Main & Tie breakers in 400kV yard in-order to carry out desired switching operations.
   c. Checking the healthiness of isolators of Main Bus-1 & 2 and bus coupler breaker in-order to carry out desired switching operations.
   d. Experienced manpower to be deputed for carrying out exercise.

   220kV Kotla jangan (PSTCL substation)

   a. Ensure that the load fed by the 100MVA transformer at 220kV Kotla jangan should not be fed from any other source at 66kV.
   b. Checking the healthiness of isolators & breakers of 220kV & 66kV bus.
   c. Experienced manpower to be deputed for carrying out exercise.

The Mock exercise would be carried out in co-ordination with NRLDC & SLDC, Patiala. Manpower may be deputed at NRLDC & SLDC, Patiala for carrying out the exercise.

2. **The entire exercise would be conducted in the following four stages. The exercise would start at 10:30 hrs**

Stage-1: Initial Switching operations

Objective is to carry out switching operations so that a subsystem is created with entire load of 220kV Kotla jangan(PSTCL) Substation being fed by one unit of Chamera-1 through 400 kV Chamera(1)-Jallandhar ckt-1, 400/220 kV ICT-I at Jallandhar, 220 kV Jallandhar-Kotla jangan feeder

Note: ***Take operational code from NRLDC to start switching operation for mock exercise.***

a. At 220/66 kV Kotla jangan (PSTCL)

Create a single in-feed for 220 kV Kotla jangan by manually opening 220 kV Jamsher ckt-1&2 and 220 k V Kartarpur. SLDC, Patiala to ensure that the loading is under control while opening the 220kV feeders. The 220 KV Kotla jangan sub-station would then be fed only from 400/220 KV Jallandhar (POWERGRID) through 220kV Jallandhar- Kotla jangan line. ***Ensure that the load fed by the 100MVA transformer at 220kV Kotla jangan should not be fed from any other source at 66kV*** i.e., the load being fed radially from 400kV Jallandhar (P.G).

b. At 400/220 kV Jallandhar (POWERGRID)

At 220kV switchyard at Jallandhar(PG)

1. Keep 400/220 kV ICT-1 and 220 kV Kotla jangan feeder on 220 kV Bus-1.
2. Other feeder & ICT (ICT-2, 220 kV Dasuya Ckt-1 &2, 220 kV Hamirpur Ckt-1 &2 and 220 kV Kartarpur) on 220 kV Bus –2.
3. Open 220 kV Bus Coupler.

Sl. No.	220 kV Bus-1 at Jallandhar (P.G)	220 kV Bus-2 at Jallandhar (P.G)
1.	Kotla jangan & ICT-1	Hamirpur-1&2, Dasuya-1&2, Kartarpur & ICT-2

At 400kV switchyard at Jallandhar(PG)

a) Keep 400 kV Chamera-1 & 400/220 kV ICT-1 on 400 kV Bus-1.
b) Other 400 KV lines and ICT's (Chamera-2, Moga Ckt-I & II, Amritsar, Ludhiana and ICT-2, Chamera_3 pooling ckt-1&2) on 400 kV Bus-2.

Sl. No.	400 kV Bus-1 at Jallandhar (P.G)	400 kV Bus-2 at Jallandhar (P.G)
1.	Chamera-1 & ICT-1	Amritsar, Ludhiana, Moga-1 & 2, Chamera-2, Chamera_3 pooling ckt-1&2 and ICT-2

c) Chamera-1 HEP (NHPC)

At 400kV switchyard at Chamera-1

1. The feeders would be re-arranged such that Unit to be self started and 400 kV Chamera_1-Jallandhar ckt-1 is connected to Bus-I.
2. Remaining Units along with 400kV Chamera_1-Jallandhar Ckt-2 & 400kV Chamera_1-Chamera_2 line would be connected to Bus-II.
3. **Keep bus coupler in <u>closed position</u> at Chamera-1.**

Sl. No.	400 kV Bus-1 at Chamera-1	400 kV Bus-2 at Chamera-1
1.	Jallandhar-1 & Unit#3(presumed to be black-started)	Jallandhar-2, Chamera-2 & Units#1 & Unit#2

Note 1: Unit#3 has been presumed as the Unit to be black-started. However, Chamera-1 HEP may decide upon the unit which will be black-started during the black-start exercise.

Note 2: It may be ensured that isolators are also opened after opening the breaker to avoid very high voltages across switched off breakers.

Stage-2: Testing of Chamera-1 unit for islanded operation and checking the synchronizing capability at Chamera-1

a. The subsystem with 220kV Kotla jangan load and Unit#3 (intended unit for black-start) at Chamera-1 HEP is coupled with the grid through 400 kV bus coupler at Chamera-1.
b. Regulate the generation at Chamera-1 unit#3(intended unit for black-start) in-order to maintain minimum power flow through 400 kV bus coupler at Chamera-1.
c. Create Island by opening the 400 kV bus coupler at 400 kV Chamera-1 HEP **after taking a code from NRLDC** and allow the subsystem to operate in islanded mode for at least 15 minutes. **The Chamera-1 HEP unit in the subsystem would have to be in free governor mode and AVR on AUTO mode**.
d. Chamera-1 has to regulate the frequency of the subsystem and operate it at 50 Hz and 50.5 Hz for 5 minutes each.
e. Now synchronize the subsystem to the grid through the 400 kV bus coupler at Chamera-1 without interrupting the load at 220kV Kotla jangan. Chamera-1 HEP would ensure that the closing is done when the smaller system (Bus-I) is approximately 10 degrees or less leading compared to the main grid viz. Bus-II.

Stage-3: Mock black start exercise

<u>Creating Blackout at 220kV Kotla jangan(PSTCL)</u>

a. At 400 kV Chamera-1 HEP

1. Open the 400 kV bus coupler at Chamera-1 HEP. This would re-create the island.
2. **Take operation code from NRLDC** and Trip Unit#3 (intended unit for black-start) breaker. This would interrupt the power supply to 220 kV Kotlajunga and de-energize 400kV Chamera_1-Jallandhar ckt-1 & 400/220 kV ICT-I at Jallandhar(PG) creating blackout in subsystem(island).
3. Open breaker of 400 kV Chamera_1-Jallandhar ckt-1.

b. At 400/220kV Jallandhar(P.G)

1. Open Main breaker of 400 kV Chamera_1-Jallandhar ckt-1 and 400/220 kV ICT-I.
2. Open 220 kV Jallandhar(PG)-Kotla jangan line from Jallandhar (PG) end

c. At 220kV Kotla jangan(PSTCL)

1. Following a loss of voltage at 220/66 kV Kotla jangan substation of PSTCL, open all 220 kV breakers & 66kV breakers at 220kV Kotla jangan.

Black-starting of Unit at Chamera(1) HEP

a. At 400 kV Chamera-1 HEP

1. Now self start unit#3(intended unit for black-start) at Chamera-1. Ensure that auxiliary supply is taken from local DG set (as would be done during a blackout). Charge the dead 400 kV Bus–1 at Chamera-1 through this unit. Chamera-1 unit#3 would be on free governor mode of operation. AVR may be kept on AUTO mode.
2. Maintain bus voltage around 380 kV by varying the excitation i.e., the AVR set point to be kept accordingly.
3. Charge the 400 kV Chamera_1-Jallandharckt-1 after taking clearance from Jallandhar (POWERGRID).

b. At 400/220 kV Jallandhar (POWERGRID)

1. Observe line voltage on 400kV Chamera_1-Jallandhar Ckt-1. The open end line voltage should not be more than 410 kV. If voltage is high, then ask Chamera-1 HEP engineers to adjust excitation of Unit to lower the open end voltage at 400kV Jallandhar(PG) to desired level. This will ensure that Over-voltage condition will not prevail while closing of Main breaker of 400kV Chamera_1-jallandhar line-1 at Jallandhar end. Wait for 2-3 minutes before closing 400 kV Main breakers of 400 kV Chamera_1-Jallandhar Ckt-1 and 400/220 kV ICT-I at Jallandhar in coordination with Chamera-1 engineers. This would energise the 400/220 kV ICT-I at Jallandhar(PG).
2. The tie breakers of 400 k V Chamera_1-Jallandhar Ckt-1 and 400/220 kV ICT-1 to be kept open.
3. Close the 220 kV side breaker of 400/220 kV ICT-1 at Jallandhar to charge 220 kV Bus-1 and charge 220 kV Jalandhar-Kotla jangan line from this bus.

c. At 220/66 kV Kotla jangan

1. After line voltage is available on Jallandhar(PG) line, charge 220 kV main bus at Kotla jangan by closing breaker of 220 kV Jallandhar-Kotla jangan line at 220kV Kotla jangan.
2. Charge 220/66 kV Transformer and connect gradually say in steps of 10 MW of the radial load at Kotla jangan on clearance from SLDC Patiala. SLDC, Patiala may co-ordinate with 220kV Kotla jangan during restoration of load.
3. Kotla jangan substation would ensure that the other 220 kV feeders viz. Jamsher ckt-1&2 and Kartarpur line ***are not closed under any circumstance***.

Observe islanded operation for about 10 to 15 minutes.

Stage-4: Restoration

a. At 400/220 kV Jallandhar (POWERGRID)

1. **Take code from NRLDC** & synchronise the island with the grid at 400 kV Jallandhar (POWERGRID).
2. **The synchronization (400kV Bus-1 & Bus-2) can be done** through closing of ICT-1 tie breaker or alternately through tie breaker of 400 kV Chamera_1-Jallandhar ckt-1.
3. Chamera-1 unit running in the islanded subsystem would do the frequency matching. The jallandhar end operator would ensure that the closing is done when the voltage and frequency of subsystem and main grid are within prescribed synchronization limits.

After synchronisation restore the system back to normal operation by:

a. Closing the 400 kV bus coupler at Chamera-1 followed by uniform arrangement of feeders on both the buses. In case any change in setting of low forward power relay or reverse power relay has been made to facilitate black start, the same may be reversed to the original setting.
b. Close the 400 kV remaining breakers at Jallandhar (POWERGRID) and 220 kV bus coupler followed by uniform arrangement of feeders at 220 kV level.
c. Close 220 kV Kotla jangan-Kartarpur line and 220 kV Kotla jangan-Jamsher ckt-1&2 circuits from Kotla jangan.
d. Normalization of all connection as prior to the start of Mock exercise.

After completion of the mock black start exercise, kindly forward your observation during the exercise.

Chamera-1 HEP

a) Observations during the exercise.

b) Changes done in protection, AVR setting & governor droop settings, modification of interlocks, Low forward power/reverse power setting, check synchronization relay setting, any other modifications done for nock exercise.

400/220kV Jallandhar POWERGRID

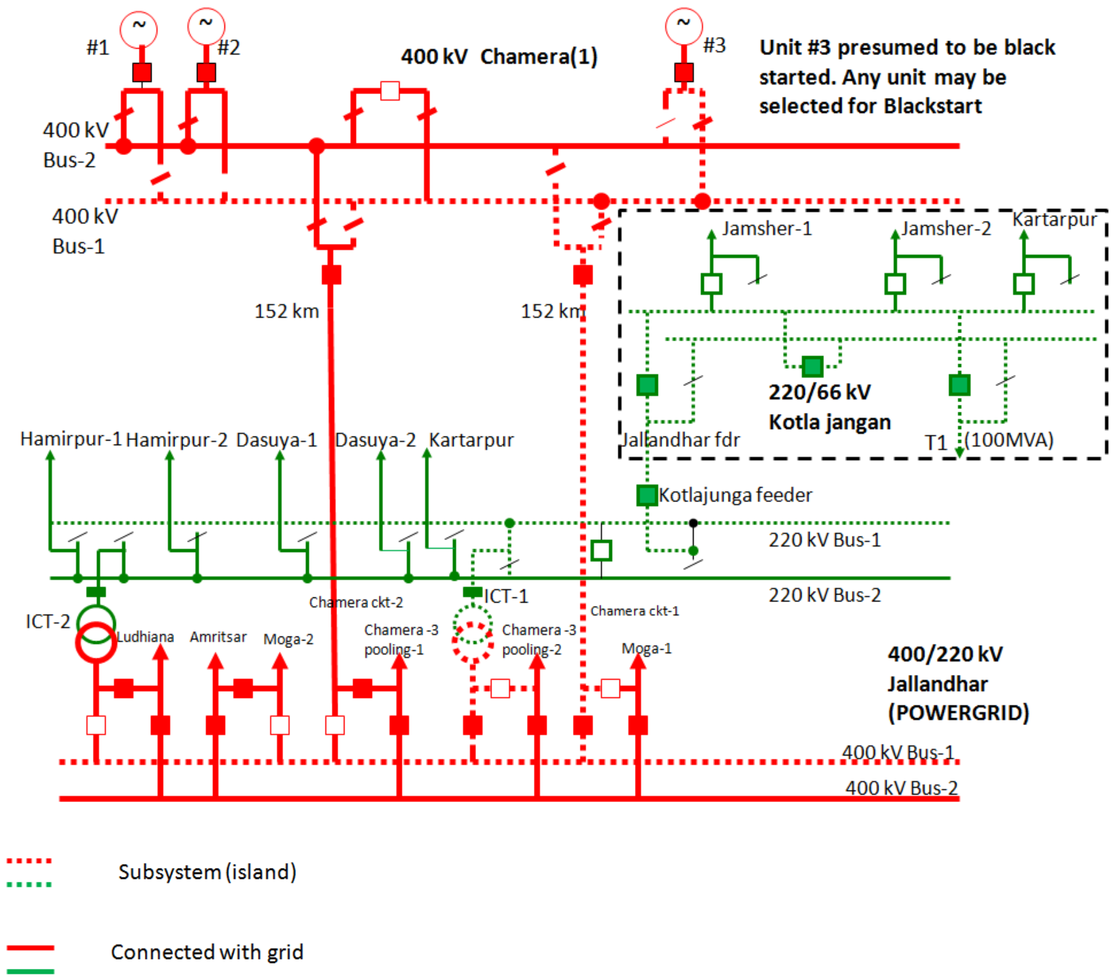
a) Observations during the exercise.

b) Changes done in protection, check synchronization relay setting, any other modifications done for nock exercise..

SLDC, Patiala

a) Observations during the exercise.

Black Start Switching Diagram of Chamera-1 HEP

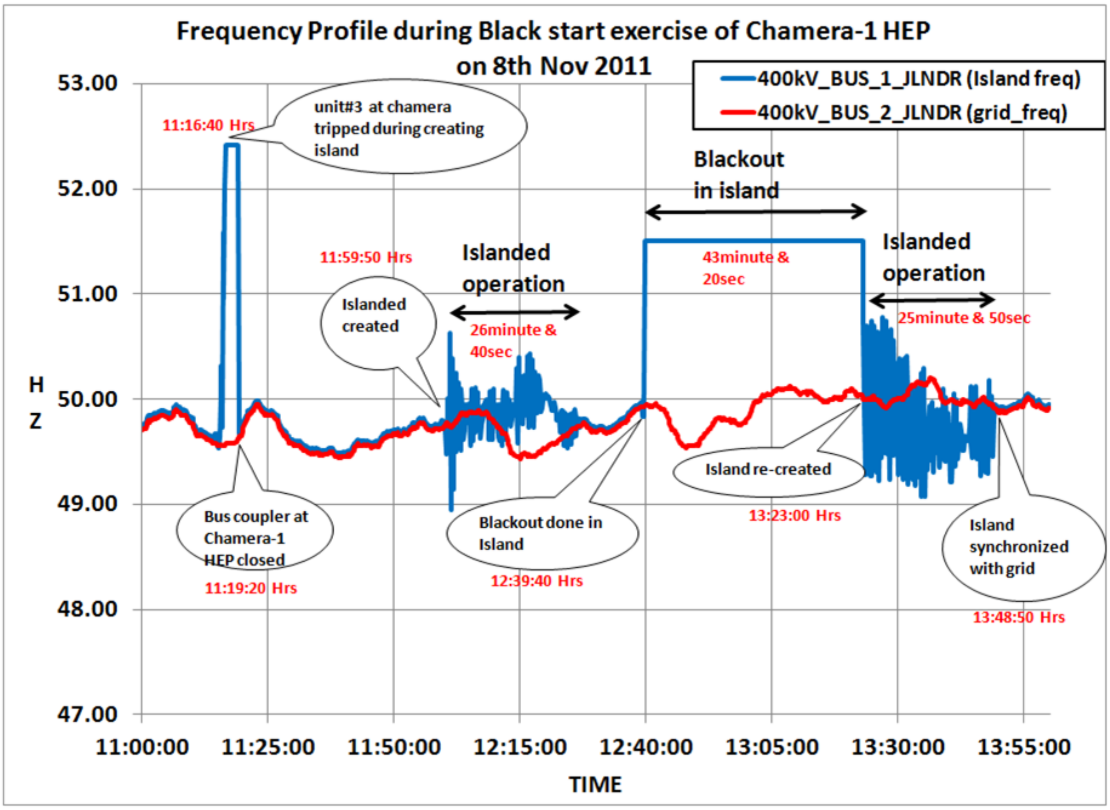


10.1.2. Details & learning from Mock Exercise

1) Unit#3 at Chamera-1 HEP was started and synchronized at 11:01hrs.
2) The island was created by opening of Bus coupler at Chamera-1 HEP. However the island collapsed at 11:16:40 hrs due to over-frequency and machine tripped on mechanical over-speeding.
3) Chamera-1 HEP closed the bus coupler at 11:19:20hrs. Unit#3 was re-started and synchronized with grid at 11:54:10 hrs. It took 37 min (approx) for Chamera-1 HEP to re-start and synchronize Unit#3.
4) The island was created again by opening bus coupler at Chamera-1 at 11:59:50hrs. Chamera-1 regulated the frequency of the subsystem and operated between at 49.0 Hz and 50.5 Hz for 26 minutes. A huge variation in frequency was observed during islanded operation. The Island was then synchronized with grid by closing of Bus coupler at Chamera-1 HEP at 12:26:20 hrs.
5) The island was re-created by opening bus coupler at Chamera-1 HEP at 12:39:10 hrs. After this the Island was collapsed at 12:39:40hrs by manually opening the breaker of the Unit#3 at Chamera-1 HEP.
6) The Island was formed at 13:23 hrs by self starting of Unit#3 at

Chamera-1 HEP, Charging 400kV Bus-1 at Chamera HEP, charging of 400kV Chamera-Jalandhar line-1, Charging of 400kV Bus-1 and ICT#1, Charging of 220kV Bus-1, 220kV Jallandhar-Kotlajangan feeder at Jallandhar(P.G), Charging of loads at 220kV Kotlajanga S/s. The islanded operation was observed for 25 minutes.

7) The Island was synchronized at 400/220kV Jallandhar(P.G)S/s at 13:48:50hrs.



8) To contain switching over-voltage during charging of long transmission lines from remote Hydro stations following step was adopted during re-creation of island. Unit#3 was self started at Chamera-1 HEP. 400kV Chamera-Jallandhar line was closed from Chamera-1 end. Unit#3 breaker was closed, and then field breaker was closed. The AVR was kept in AUTO mode and the voltage was maintained at around 380kV(Bus-1) at Chamera-1 HEP.

10.2 Uri HEP Black Start Exercise

10.2.1. Procedure

In order to facilitate the mock black start exercise of Uri Power house following switching operation is being suggested at 400/220 kV Wagoora (POWERGRID), Uri and 220 kV Zainakot (PDD). During this exercise the supply at 220 kV Zainakot (PDD) will be affected.

The following preliminary preparations are to be done prior to the start of mock exercise i.e., before 10:30 A.M.

1. **Preparation**

   Uri HEP

   a. Check the preparedness to start one hydro unit using auxiliary supply from the DG set.
   b. Check the possibility to charge a dead 400 KV bus with the black start unit. Interlocks, if any, in the SCADA system might need to be modified in case it inhibits this activity.
   c. Check the necessary settings to smoothly vary the excitation of the black-start unit over the entire range of the generator capability curve so that the 400 KV bus voltages can be smoothly varied.
   d. Settings of the low forward power relay/reverse power relay installed on the generating units and manufacturer's recommendations for this relay settings, if any, during black-start process.
   e. Ability to vary the governor droop setting so as to accommodate block load additions without any problem.
   f. Ability to vary the frequency of the islanded system over a large range from 48.5 Hz- 50.5 Hz.
   g. The check synchronizing relay settings at Uri HEP available for generating units, lines and 400 kV bus coupler.
   h. Manpower to be deputed for carrying out exercise & witnessing the exercise for learning.

   400/220kV Wagoora (PG) Substation

   a. Checking the healthiness of synchronizing trolley at 400kV Wagoora Substation.
   b. Checking the healthiness of Main & Tie breakers in 400kV switchyard in-order to carry out desired switching operations.
   c. Ensure availability of maximum no transformers (400/220kV) to avoid any overloading.
   d. Checking the healthiness of isolators of Main Bus-1 & 2, transfer bus and bus coupler breaker in-order to carry out desired switching operations.
   e. Manpower to be deputed for carrying out exercise & witnessing the exercise for learning.

   220kV Zainakot Substation (PDD substation)

   a. Ensure that the load fed by the 132/33kV transformers at 220/132kV Zainakot should not be fed from any other source at 33kV.
   b. Since the 132/33kV ICT's (load at Zainakot) along with 01 No. 220/132kV ICT would participate in the exercise and would be in the subsystem, other loads shall be regulated & kept so that balance 220/132kV ICT's (namely #2 & #3) don't get overloaded and their loading remains below say 150MVA.

c. The cumulative loading on the 220/132kV transformer banks-1,2 & 3 (150 MVA each) should be kept not more than around 1400 Amperes i.e., around 315 MW before start of the exercise. This is required to avoid overloading of transformer bank-2 & 3 during formation of island.
d. The island formed by 132/33kV ICT's (load at Zainakot) along with 01 No. 220/132kV ICT should have load of around 40MW or less.
e. It is understood that the 132/33kV ICT's at Zainakot are operated in parallel.
f. Ensure the healthiness of Bus coupler at both 220kV and 132kV.
g. Checking the healthiness of isolators & breakers of 220kV & 132kV bus.
h. Manpower to be deputed for carrying out exercise & witnessing the exercise for learning.

The Mock exercise would be carried out in co-ordination with NRLDC & SLDC, Bemina, Uri HEP, CPCC Jammu & Wagoora (P.G) Substation. Manpower to be deputed at NRLDC & SLDC, Bemina, Uri HEP, CPCC Jammu & Wagoora (P.G) Substation for carrying out the exercise and witnessing for learning.

2. The entire exercise would be conducted in the following four stages. The exercise would start at 10:30 hrs

Stage-1: Initial Switching operations

Objective is to carry out switching operations so that a subsystem is created with identified load of 220kV Zainakot (PDD) Substation being fed by one unit of Uri HEP through 400 kV Uri-Wagoora ckt-1, 400/220 kV ICT-I at Wagoora(PG), 220 kV Wagoora(PG)-Zainakot ckt- 1

Note: ***Take operational code from NRLDC to start switching operation for mock exercise.***

a. At 220/132 kV Zainakot (PDD)

At 132kV switchyard at Zainakot

1. Take the 132kV reserve bus into service by closing the 132kV Bus coupler.
2. Keep 132/33kV transformer's (transformers#1,#2,#3 & #4) at Zainakot on 132 kV reserve bus.
3. Keep the other feeders, 132kV Bemina ckt-1 &2, 132kV Waganpura ckt-1 &2, 132kV pattan Ckt-1&2 on 132 kV Main Bus.
4. Open 132 kV Bus Coupler.

Sl. No.	132 kV reserve Bus at Zainakot (PDD)	132 kV Main Bus at Zainakot (PDD)
1.	132/33kV transformers 1,2,3 & 4	132kV Bemina ckt-1&2, 132kV Waganpura ckt-1&2, 132kV Pattan Ckt 1&2

At 220kV switchyard at Zainakot

1. Take the 220kV reserve bus into service by closing the 220kV Bus coupler.
2. Keep 220/132 kV ICT-1(Bank-1) and 220 kV Wagoora-Zainakot ckt-1 on 220 kV Bus reserve bus.
3. Other feeder & ICT's (ICT bank 2 & 3), 220 kV Wagoora-Zainakote Ckt-2, on 220 kV Main Bus.
4. Open 220 kV Bus Coupler.

Sl. No.	220 kV reserve Bus at Zainakot (PDD)	220 kV Main Bus at Zainakot (PDD)
1.	220/132kV ICT bank-1, 220kV Wagoora-Zainakot ckt-1	ICT bank-2 & 3, 220kV Wagoora-Zainakot ckt-2

After the above arrangement, the local load at 220/132 kV Zainakot sub-station would then be fed only from 400/220 KV ICT-1 at Wagoora (POWERGRID) and through 220kV Wagoora-Zainakot ckt-1. ***Ensure that the load fed by the 132/33 kV transformers at 220kV Zainakot substation should not be fed from any other source at 33kV*** i.e., the load being fed radially from 400/220kV Wagoora (P.G).

Note: SLDC, Bemina to ensure that the loading is under control. While carrying out the exercise, the load on 220/132kV transformer bank -2 and bank-3 should be kept around 600 Amperes (each) or less i.e., around 135MW to avoid overloading.

b. At 400/220 kV Wagoora (POWERGRID)

At 220kV switchyard at Wagoora(PG)

1. Keep 400/220 kV ICT-1 and 220 kV Zainakot ckt-1 on 220 kV Bus-1.
2. Other feeders & ICT (ICT-2, ICT-3, ICT-4, 220kV Zainakot-2, 220 kV Pampore Ckt-1 &2) on 220 kV Bus-2.
3. Open 220 kV Bus Coupler.

Sl. No.	220 kV Bus-1 at Wagoora (P.G)	220 kV Bus-2 at Wagoora (P.G)
1.	Zainakot ckt-1, ICT-1	Zainakot ckt-2, Pampore ckt-1 &2, ICT-2, ICT-3 & ICT-4

At 400kV switchyard at Wagoora(P.G)

1. Keep 400 kV Uri-Wagoora-1 & 400/220 kV ICT-1 on 400 kV Bus-1.
2. Other 400 KV lines and ICT's (Uri-2, Kishenpur ckt-1&2, ICT-2, ICT-3 & ICT-4 on 400 kV Bus-2).
3. Open the 400kV bus coupler.

Sl. No.	400 kV Bus-1 at Wagoora (P.G)	400 kV Bus-2 at Wagoora (P.G)
1.	Uri-Wagoora-1, ICT-1	Uri-Wagoora-2, Wagoora-Kishenpur ckt-1&2, ICT-2, ICT-3 & ICT-4

c. Uri HEP (NHPC)

At 400kV switchyard at Uri HEP

1. The feeders would be re-arranged such that Unit to be self started and 400 kV Uri-Wagoora-1 is connected to Bus-1.
2. Remaining Units along with 400kV Uri-Wagoora Ckt-2 would be connected to Bus-II.
3. **Keep bus coupler in <u>closed position</u> at Uri HEP.**

Sl. No.	400 kV Bus-1 at Uri HEP	400 kV Bus-2 at Uri HEP
1.	Uri-Wagoora-1 & Unit#3(presumed to be black-started)	Uri-Wagoora-2, Units#1, Unit#2, Unit#4

Note 1: Unit#3 is presumed to be black-started. However, Uri HEP may decide upon the unit which will be black-started during the black-start exercise.

Note 2: It may be ensured that isolators are also opened after opening the breaker to avoid very high voltages across switched off breakers at all locations.

Stage-2: Testing of Uri unit for islanded operation and checking the synchronizing capability at Uri HEP

a. The subsystem with 220kV Zainakot load and Unit#3 (intended unit for black-start) at Uri HEP is coupled with the grid through 400 kV bus coupler at Uri HEP.
b. Regulate the generation at Uri HEP unit#3(intended unit for black-start) in-order to maintain minimum power flow through 400 kV bus coupler at Uri HEP.
c. Create Island by opening the 400 kV bus coupler at 400 kV Uri HEP **after taking a code from NRLDC** and allow the subsystem to operate in islanded mode for at least 15 minutes. **The Uri HEP unit in the subsystem would have to be in free governor mode and AVR on AUTO mode**.
d. Uri HEP has to regulate the frequency of the subsystem and operate it at 50 Hz and 50.5 Hz for 5 minutes each.
e. Now synchronize the subsystem to the grid through the 400 kV bus coupler at Uri HEP without interrupting the load at 220kV Zainakot.

Stage-3: Mock black start exercise

Creating Blackout at 220kV Zainakot (PDD)

a. At 400 kV Uri HEP

1. Open the 400 kV bus coupler at Uri HEP. This would re-create the island.
2. **Take operation code from NRLDC** and Trip Unit#3 (intended unit for black-start) breaker. This would interrupt the power supply to island formed with load of 220 kV Zainakote and de-energize 400kV Uri-Wagoora ckt-1 & 400/220 kV ICT-I at Wagoora(P.G) creating blackout in subsystem(island).
3. Open breaker of 400 kV Uri-Wagoora ckt-1.

b. At 400/220kV Wagooora(P.G)

1. Open Main breaker of 400 kV Uri-Wagoora ckt-1 and 400/220 kV ICT-I.
2. Open 220 kV Wagoora(P.G)-Zainakot ckt-1 from Wagoora (PG) end

c. At 220kV Zainakot(PDD)

1. Following a loss of voltage in the subsystem formed with load at 220/132 kV Zainakot substation, open the breaker of 220kV Wagoora-Zainakot ckt-1, 220/132kV ICT Bank-1 & breakers of 132/33 kV transformer banks (1,2,3 & 4) at 220kV Zainakot.

Black-starting of Unit at Uri HEP

a. At 400 kV Uri HEP

1. Now self start unit#3(intended unit for black-start) at Uri HEP. Ensure that auxiliary supply is taken from local DG set (as would be done during a blackout). Charge the dead 400 kV Bus–1 at Uri HEP through this unit. Uri HEP unit#3 (intended unit for black-start) would be on free governor mode of operation. AVR may be kept on AUTO mode.
2. Maintain bus voltage around 380 kV by varying the excitation i.e., the AVR set point to be kept accordingly.
3. Charge the 400 kV Uri-Wagoora ckt-1 after taking clearance from Wagoora (POWERGRID).

b. At 400/220 kV Wagoora (POWERGRID)

1. Observe line voltage on 400kV Uri-Wagoora Ckt-1. The open end line voltage should not be more than 410 kV. If voltage is high, then ask Uri HEP engineers to adjust excitation of Unit to lower the open end voltage at 400kV Wagoora(P.G) to desired level. This will ensure that Over-voltage condition will not prevail while closing the breaker of 400kV Uri-Wagoora line-1 at Wagoora(P.G) end. If the voltage is within desired limits, close 400 kV breakers of 400 kV Uri-Wagoora Ckt-1 and 400/220 kV ICT-I at Wagoora(P.G) in coordination with Uri HEP engineers. This would energise the 400/220 kV ICT-I at Wagoora(PG) and energize 220kV Bus-1 at Wagoora(P.G).
2. The 400kV bus coupler to be kept open.
3. Close breaker of 220 kV Wagoora-Zainakot ckt-1.
4. The 220kV bus coupler is to be kept open.

c. At 220/132 kV Zainakot

1. After line voltage is available on 220kV Wagoora(PG)-Zainakot Ckt-1, charge 220 kV reserve bus at Zainakot by closing breaker of 220 kV Wagoora(P.G)-Zainakot ckt-1 at 220kV Zainakot.
2. Charge 220/132kV transformer bank-1 which will energise 132kV reserve bus.
3. Charge 132/33kV transformer banks (1,2,3 & 4). This will charge the 33kV Bus at Zainakot. Connect the 33kV radial load gradually say in steps of 10 MW at Zainakot on clearance from SLDC, Bemina. SLDC, Bemina may co-ordinate with 220kV Zainakot during restoration of load.
4. Zainakot substation would ensure that the 220 & 132kV bus coupler is ***not closed under any circumstance***.

Observe islanded operation for about 10 to 15 minutes.

Stage-4: Restoration

a. At 400/220 kV Wagoora (POWERGRID)

1. **Take code from NRLDC** & synchronise the island with the grid at 400 kV Wagoora (POWERGRID).
2. **The synchronization (400kV Bus-1 & Bus-2) can be done** through closing of Bus coupler of 400kV bus or alternately through Bus coupler of 220kV Bus.
3. Uri HEP unit running in the islanded subsystem would carry out the frequency matching. The Wagoora end operator would ensure that the

closing is done when the voltage and frequency of subsystem and main grid are within prescribed synchronization limits.

Note : Close co-ordination is required between Wagoora (P.G) substation, Uri HEP & Zainakot Substation for regulating generation, load & synchronizing.

After synchronisation restore the system back to normal operation by:

a. Closing the 400 kV bus coupler at Uri HEP followed by uniform arrangement of feeders on both the buses. In case any change in setting of low forward power relay or reverse power relay has been made to facilitate black start, the same may be reversed to the original setting.
b. Uniform arrangement of 400 kV feeders and closing of 220 kV bus coupler followed by uniform arrangement of feeders at 220 kV level at Wagoora (P.G).
c. Close the 220kV and 132kV Bus couplers followed by uniform arrangement of 132kV feeders from 220kV Zainakot substation.
d. Normalization of all connection as prior to the start of Mock exercise.

After completion of the mock black start exercise, kindly forward your observation during the exercise.

Uri HEP

c) Observations during the exercise.
d) Changes done in protection, AVR setting & governor droop settings, modification of interlocks, Low forward power/reverse power setting, check synchronization relay setting, any other modifications done for nock exercise.

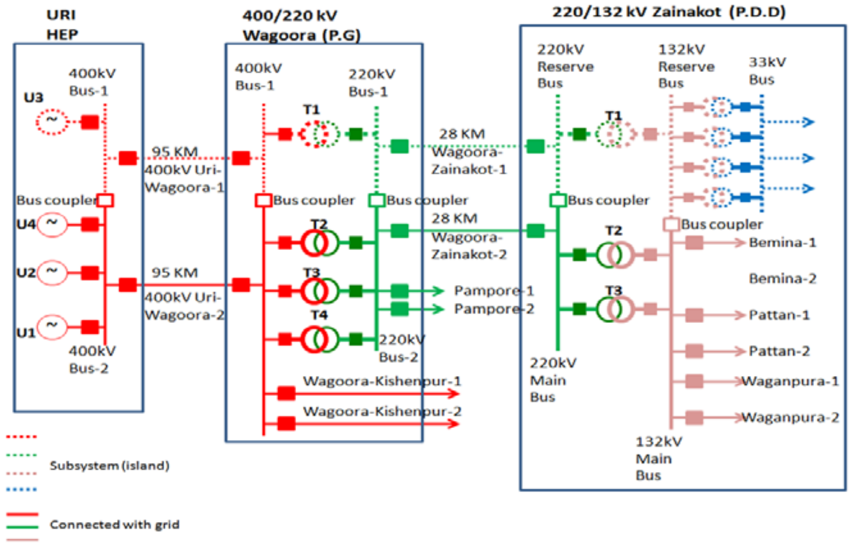
400/220kV Wagoora POWERGRID

c) Observations during the exercise.
d) Changes done in protection, check synchronization relay setting, any other modifications done for nock exercise.

SLDC, Bemina

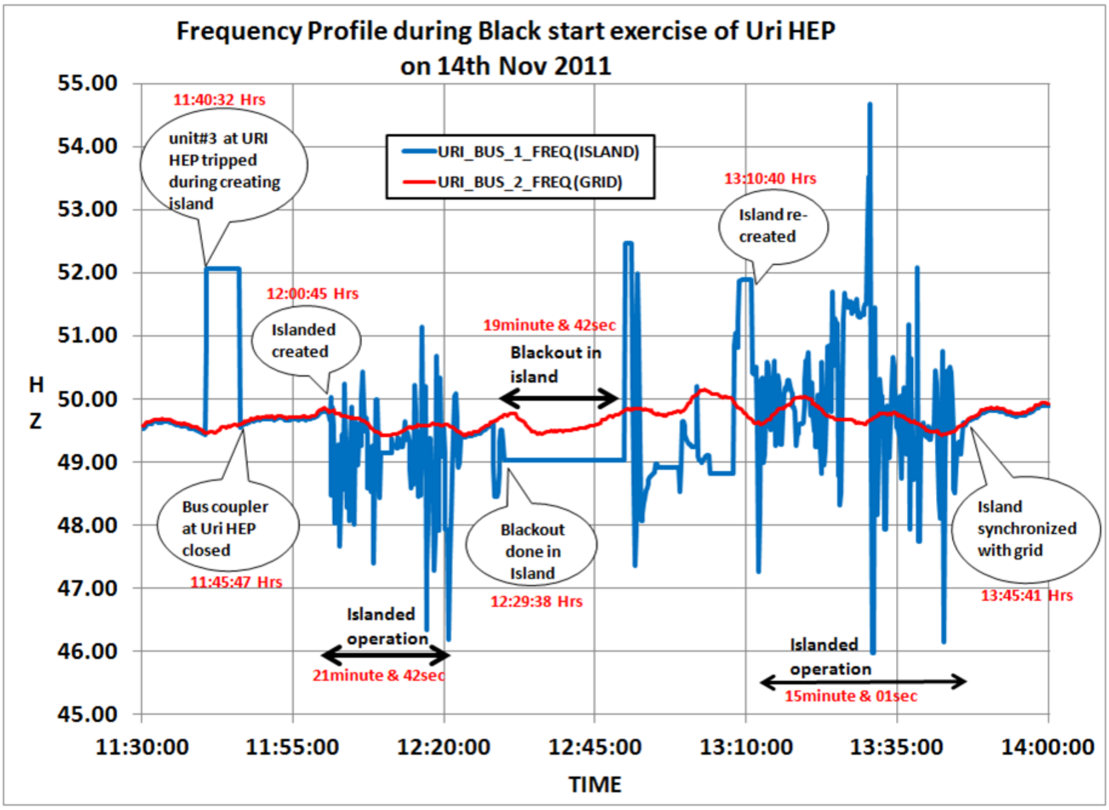
b) Observations during the exercise.

Uri HEP Black Start Switching Diagram



10.2.2. Details & learning from Mock Exercise

1) A mock self start exercise for Uri Hydro power station was carried out on 14th November 2011 between 1100-1400 hours.
2) The exercise involved :
    a. Creation of a subsystem with unit#3 at Uri HEP, 400kV Bus-1 at Uri HEP, 400kV Uri- Wagoora line-1, 400kV Bus-1 at Wagoora(P.G), 400/220kV, 315MVA ICT-1 at 400kV Wagoora(P.G) S/s, 220kV Bus-1, 220kV Wagoora-Zainakot ckt-1, Load at 220/132/33kV Zainakot Substation (PDD).
    b. The 400kV Buses at 400kV URI HEP, 400kV & 220kV buses at Wagoora(P.G), 220kV & 132kV Buses at Zainakot substation (PDD) were split for carrying out the exercise.
    c. The Subsystem was created by opening bus coupler at Uri HEP and islanded operation was observed for few minutes. The subsystem was then synchronised with grid at Uri HEP by closing of Bus-coupler at Uri HEP.
    d. The subsystem was again re-created by opening bus coupler at Uri HEP and then collapsed by tripping Unit#3 at Uri HEP.
    e. The subsystem was formed by self starting the unit#3 at Uri HEP and charging the subsystem, island was observed for few minutes and synchronized with grid at 400/220kV Wagoora(P.G).



10.3 Karcham Wangtoo HEP Black Start Exercise

10.3.1. Procedure

In order to facilitate the mock black start exercise of Karcham Wangtoo Power house following switching operation is being suggested at Karcham Wangtoo HEP, Jhakri HEP, 400/220 kV Abdullapur (POWERGRID), 220/66 kV Jorian (HVPNL). During this exercise the supply at 220/66 kV Jorian (HVPNL) will be affected.

The following preliminary preparations are to be done pr ior to the start of mock exercise i.e., before 10:30 A.M.

1. **Preparation**

   Karcham Wangtoo HEP

   a. Check the preparedness to start one hy dro unit using auxiliary supply from the DG set.
   b. Check the possibility to charge a dead 400 KV bus with the black start unit. Interlocks, if any, in the SCADA system might need to be modified in case it inhibits this activity.
   c. Check the necessary settings to smoothly vary the excitation of the black-start unit over the entire range of the generator capability curve so that the 400 KV bus voltages can be smoothly varied.
   d. Settings of the low forward power relay/reverse power relay installed on the generating units and manufacturer's recommendations for this relay settings, if any, during black-start process.
   e. Ability to vary the governor droop setting so as to accommodate block load additions without any problem.
   f. Ability to vary the frequency of the islanded system over a large range from 48.5 Hz- 50.5 Hz.
   g. The check synchronizing relay settings at Karcham Wangtoo HEP available for generating units, lines and 400 kV bus coupler.
   h. Manpower to be deputed for carrying out exercise & witnessing the exercise for learning.
   i. SPS at Karcham Wangtoo HEP may be disabled during the exercise.

   400kV Jhakri HEP

   a. Checking the healthiness of isolators & breaker connected to 400kV Bus-1 & 2, in-order to carry out desired switching operations.
   b. Manpower to be deput ed for carrying out exercise & witnessing the exercise for learning.

   400/220kV Abdullapur (PG) Substation

   a. Checking the healthiness of synchronizing trolley at 400kV Abdullapur Substation.
   b. Checking the healthiness of Main & Tie breakers in 400kV switchyard in-order to carry out desired switching operations.
   c. Ensure availability of maximum no transformers (400/220kV) to avoid any overloading.
   d. Manpower to be deput ed for carrying out exercise & witnessing the exercise for learning.

220/66kV Jorian Substation (HVPNL)

a. Ensure that the load fed by the 220/66kV transformers at 220/66kV Jorian should not be fed from any other source at 66kV.
b. The island formed by 220/66kV transformers should have load of around 30-40MW.
c. Checking the healthiness of isolators & breakers of 220kV & 66kV bus in-order to carry out desired switching operations.
d. Manpower to be deput ed for carrying out exercise & witnessing the exercise for learning.

The Mock exercise would be carried out in co-ordination with NRLDC & SLDC, Panipat (HVPN), Karcham Wangtoo HEP, Jhakri HEP, CPCC Jammu & Abdullapur (P.G) Substation. Manpower to be deput ed at NRLDC & SLDC(Panipat), Karcham Wangtoo HEP, CPCC Jammu & Abdullapur (P.G) Substation for carrying out the exercise and witnessing for learning.

2. The entire exercise would be conducted in the following four stages. The exercise would start at 10:30 hrs

Stage-1: Initial Switching operations

Objective is to carry out switching operations so that a subsystem is created with identified load of 220/66kV Jorian (HVPNL) Substation being fed by one unit of Karcham Wangtoo HEP through 400 kV Karcham-NJPC ckt-1, 400kV NJPC-Abdullapur ckt-1, 400/220 kV ICT-I at Abdullapur(PG), 220 kV Abdullapur-Jorian ckt- 1.

Note: ***Take operational code from NRLDC to start switching operation for mock exercise.***

a. At 220/66 kV Jorian (HVPNL)

At 220kV switchyard at Jorian

1. Keep 220/66kV transformer-1, transformer-2 and 220kV Jorian-Abdullapur ckt-1 at Jorian on 220kV Bus-1.
2. Keep the other feeders (220kV Jorian-Abdullapur-2, Jorian-Shahbad ckt-1&2, 220kV Jorian-Yamunanagar ckt-1&2) on 220kV Bus-2.
3. Open 220 kV Bus Coupler.

Sl. No.	220 kV Bus-1 at Jorian(HVPNL)	220 kV Bus-2 at Jorian(HVPNL)
1.	220/66kV transformer-1, transformer-2 & 220kV Jorian-Abdullapur ckt-1	220kV Jorian-Abdullapur-2, Jorian-Shahbad ckt-1&2, 220kV Jorian-Yamunanagar ckt-1&2

At 66 kV switchyard at Jorian (HVPNL)

1. During islanded operation the loading needs to be in the range of 30-40MW. Hence, accordingly the 66kV feeders may be kept in service.

After the above arrangement, the local load at 220/66 kV Jorian sub-station (HVPNL) would then be fed only from 400/220 KV ICT-1 at Abdullapur(POWERGRID) and through 220kV Abdullapur(P.G)-Jorian ckt-1.

Note: SLDC, Panipat to ensure that the loading is under control.

b. At 400/220 kV Abdullapur (POWERGRID)

At 220kV switchyard at Abdullapur (PG)

1. Keep 400/220 kV ICT-1, 220 kV Jorian ckt-1 on 220 kV Bus-1.
2. Other feeders & ICT (ICT-2, ICT-3, 220kV Tepla ckt-1, 220kV DCRTP ckt-1&2, 220kV Railway Ckt-1 &2) on 220 kV Bus-2.
3. Open 220 kV Bus Coupler.

Sl. No.	220 kV Bus-1 at Abdullapur (P.G)	220 kV Bus-2 at Abdullapur (P.G)
1.	400/220 kV ICT-1, 220 kV Jorian ckt-1	ICT-2, ICT-3, 220kV Tepla ckt-1, 220kV DCRTP ckt-1&2, 220kV Railway Ckt-1 &2

At 400kV switchyard at Abdullapur (P.G)

At 400 k V switchyard at Abdullapur, the 400/220 kV ICT-I and 400 k V Abdullapur-NJPC-1 are in the same diameter, therefore bus splitting is not required at 400 kV Abdullapur. Only following operations shall be carried out.

i. Open 400 kV main breaker of 400/220 kV ICT-I
ii. Open 400 kV main breaker of 400 kV Abdullapur-NJPC-1
iii. Tie-breaker of the above feeders would be kept closed.

Note: The 50 MVAR & 125 MVAR bus reactors may be connected depending on the voltage.

c. Jhakri HEP

At 400kV switchyard at Jhakri HEP

1. The feeders would be re-arranged such that 400 kV Karcham-NJPC ckt-1 & 400kV NJPC-Abdullapur ckt-1 are connected to Bus-1.
2. All Units along with 400kV Karcham-NJPC Ckt-2, 400kV NJPC-Abdullapurckt-2, 400kV NJPC-Nalagarh ckt-1&2 would be connected to Bus-2.
3. **Open the bus coupler at Jhakri HEP.**

Sl. No.	400 kV Bus-1 at NJPC HEP	400 kV Bus-2 at NJPC HEP
1.	400 kV Karcham-NJPC ckt-1 & 400kV NJPC-Abdullapur ckt-1	All Units, 400kV Karcham-NJPC Ckt-2, 400kV NJPC-Abdullapurckt-2, 400kV NJPC-Nalagarh ckt-1&2

d. Karcham Wangtoo HEP

At 400kV switchyard at Karcham wangtoo HEP

1. The feeders would be re-arranged such that Unit to be self started and 400 kV Karcham-NJPC ckt-1 is connected to Bus-1.
2. Remaining Units along with 400kV Karcham-NJPC Ckt-2, 400kV Karcham-BASPA ckt-1&2 would be connected to Bus-2.
3. **Keep bus coupler in <u>closed position</u> at Karcham Wangtoo HEP.**

Sl. No.	400 kV Bus-1 at Karcham HEP	400 kV Bus-2 at Karcham HEP
1.	400 kV Karcham-NJPC ckt-1 & Unit#3(presumed to be black-started)	400 kV Karcham-NJPC ckt-2, 400kV Karcham-BASPA ckt- 1&2, Units#1, Unit#2, Unit#4

Note 1: Unit#3 is presumed to be black-started. However, Karcham wangtoo HEP may decide upon the unit which will be black-started during the black-start exercise.

Note 2: It may be ensured that isolators are also opened after opening the breaker to avoid very high voltages across switched off breakers at all locations.

Stage-2: Testing of Karcham Wangtoo unit for islanded operation and checking the synchronizing capability at Karcham Wangtoo HEP

a. The subsystem with 220kV Jorian load and Unit#3 (intended unit for black-start) at Karcham Wangtoo HEP is coupled with the grid through 400 kV bus coupler at Karcham Wangtoo HEP.
b. Regulate the generation at Karcham Wangtoo HEP unit#3 (intended unit for black-start) in-order to maintain minimum power flow through 400 kV bus coupler at Karcham Wangtoo HEP.
c. Create Island by opening the 400 kV bus coupler at 400 kV Karcham Wangtoo HEP **after taking a code from NRLDC** and allow the subsystem to operate in islanded mode for at least 15 minutes. **The Karcham Wangtoo HEP unit in the subsystem would have to be in free governor mode and AVR on AUTO mode**.
d. Karcham Wangtoo HEP has to regulate the frequency of the subsystem and operate it at 50 Hz and 50.5 Hz for 5 minutes each.
e. Now synchronize the subsystem to the grid through the 400 kV bus coupler at Karcham Wangtoo HEP without interrupting the load at 220kV Jorian.

Stage-3: Mock black start exercise

<u>Creating Blackout at 220kV Jorian</u>

a. At 400 kV Karcham Wangtoo HEP

1. Open the 400 kV bus coupler at Karcham Wangtoo HEP. This would re-create the island.
2. **Take operation code from NRLDC** and Trip Unit#3 (intended unit for black-start) breaker. This would interrupt the power supply to island formed with load of 220 kV Jorian and de-energize 400kV Karcham-NJPC ckt-1, 400kV NJPC-Abdullapur ckt-1, 400/220 kV ICT-I at Abdullapur(P.G) creating blackout in subsystem(island).
3. Open breaker of 400 kV Karcham-NJPC ckt-1.

b. At 400 kV NJPC HEP

1. Open the breaker of 400kV Karcham-NJPC-1 & 400kV NJPC-Abdullapur ckt-1.

c. At 400/220kV Abdullapur(P.G)

1. Open Tie breaker of 400 kV NJPC-Abdullapur ckt-1 and 400/220 kV ICT-I.
2. Open 220 kV Abdullapur(P.G)-Jorian ckt-1.

d. At 220kV Jorian(HVPNL) substation

1. Following a loss of voltage in the subsystem formed with load at 220/66 kV Jorian substation, open the breaker of 220kV Abdullapur-Jorian ckt-1, transformer-1&2 & open breakers of 66kV feeders which were kept in service.

Black-starting of Unit at Karcham Wangtoo HEP

a. At 400 kV Karcham Wangtoo HEP

1. Now self start unit#3(intended unit for black-start) at Karcham Wangtoo HEP. Ensure that auxiliary supply is taken from local DG set (as would be done during a blackout). Charge the dead 400 kV Bus–1 at Karcham wangtoo HEP through this unit. Karcham Wangtoo HEP unit#3 (intended unit for black-start) would be on free governor mode of operation. AVR may be kept on AUTO mode.
2. Maintain bus voltage around 380 kV by varying the excitation i.e., the AVR set point to be kept accordingly.
3. Charge the 400 kV Karcham-NJPC ckt-1 after taking clearance from NJPC and code from NRLDC.

b. At 400 kV NJPC HEP

1. Charge the 400 kV Karcham-NJPC ckt-1 & NJPC-Abdullapur ckt-1 after taking clearance from Karcham & Abdullapur(P.G). Take code from NRLDC.

c. At 400/220 kV Abdullapur (POWERGRID)

1. Observe line voltage on 400kV NJPC-Abdullapur Ckt-1. The open end line voltage should not be more than 410 kV. If voltage is high, then ask Karcham HEP engineers to adjust excitation of Unit to lower the open end voltage at 400kV Abdullapur(P.G) to desired level. This will ensure that Over-voltage condition will not prevail while closing the Tie breaker of 400kV NJPC-Abdullapur line-1 & ICT-1 at Abdullapur(P.G) end. If the voltage is within desired limits, close 400 kV tie breaker of 400 kV NJPC-Abdullapur Ckt-1 and 400/220 kV ICT-I at Abdullapur(P.G) in coordination with Karcham Wangtoo HEP engineers. This would energise the 400/220 kV ICT-I at Abdullapur(PG).
2. Close breaker of 220 kV Abdullapur-Jorian ckt-1.
3. The 220kV bus coupler along with the Main breakers of 400 kV NJPC-Abdullapur Ckt-1 and 400/220 kV ICT-I are to be kept open.

d. At 220/66 kV Jorian

1. After line voltage is available on 220kV Abdullapur(PG)-Jorian Ckt-1, charge 220 kV bus-1 at Jorian by closing breaker of 220 kV Abdullapur-Jorian ckt-1 at 220kV Jorian.
2. Charge 220/66kV transformer-1&2 which will energise 66kV bus.
3. Connect the 66kV radial load gradually say in steps of 10 MW at Jorian on clearance from SLDC, Panipat. SLDC, Panipat may co-ordinate with 220kV Jorian during restoration of load.
4. The load should be in the range of 30-40MW.
5. Jorian substation would ensure that the 220kV bus coupler is ***not closed under any circumstance***.

Observe islanded operation for about 10 to 15 minutes.

Stage-4: Restoration

At 400/220 kV Abdullapur (POWERGRID)

1. **Take operational code from NRLDC** & synchronise the island (subsystem) with the grid at 400 kV Abdullapur (POWERGRID).

2. The synchronization of island with grid can be done through closing of 400 kV Main breaker of 400 kV Abdullapur-NJPC-1 or Main breaker of 400/220 kV ICT-I at Abdullapur or alternately through Bus coupler of 220kV Bus.
3. Karcham Wangtoo HEP unit running in the islanded subsystem would carry out the frequency matching. The Abdullapur end operator would ensure that the closing is done when the voltage and frequency of subsystem and main grid are within prescribed synchronization limits.

Note: Close co-ordination is required between Abdullapur (P.G) substation, Karcham wangtoo HEP, Jhakri HEP & Jorian Substation for regulating generation, load & synchronizing.

After synchronisation restore the system back to normal operation by:

a. Closing the 400 kV bus coupler at Karcham Wangtoo HEP followed by uniform arrangement of feeders on bot h the buses. In case any change in setting of low forward power relay or reverse power relay has been made to facilitate black start, the same may be reversed to the original setting.
b. Closing of Bus coupler at Jhakri HEP followed by uniform arrangement of feeders on both the buses.
c. Closing of 220 kV bus coupler followed by uniform arrangement of feeders at 220 kV level at Abdullapur (P.G).
d. Close the 220kV Bus coupler followed by charging of remaining 66kV feeders from 220kV Jorian substation.
e. Normalization of all connection as prior to the start of Mock exercise.

After completion of the mock black start exercise, kindly forward your observation during the exercise.

Karcham Wangtoo HEP

a) Observations during the exercise.
b) Changes done in protection, AVR setting & governor droop settings, modification of interlocks, Low forward power/reverse power setting, check synchronization relay setting, any other modifications done for nock exercise.

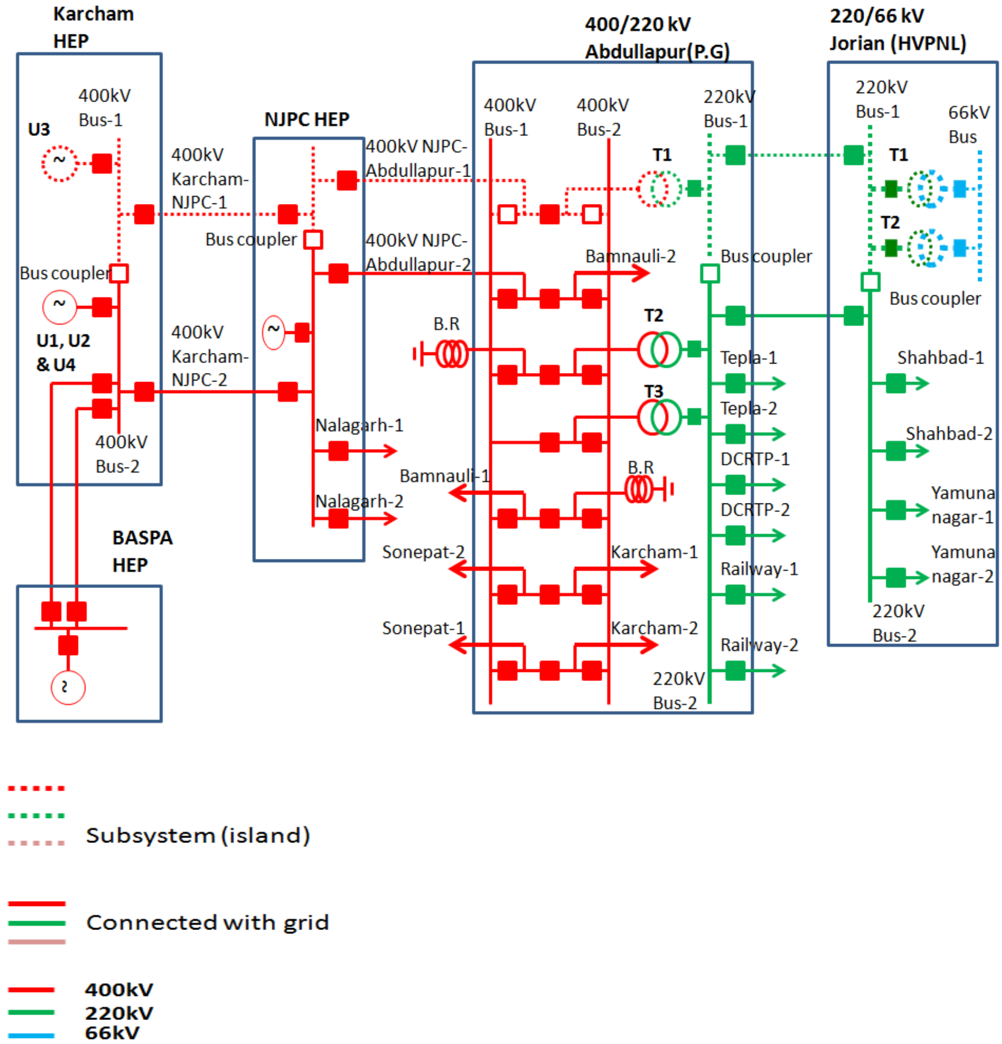
400/220kV Abdullapur POWERGRID

a) Observations during the exercise.
b) Changes done in protection, check synchronization relay setting, any other modifications done for nock exercise.

SLDC, Panipat (HVPN)

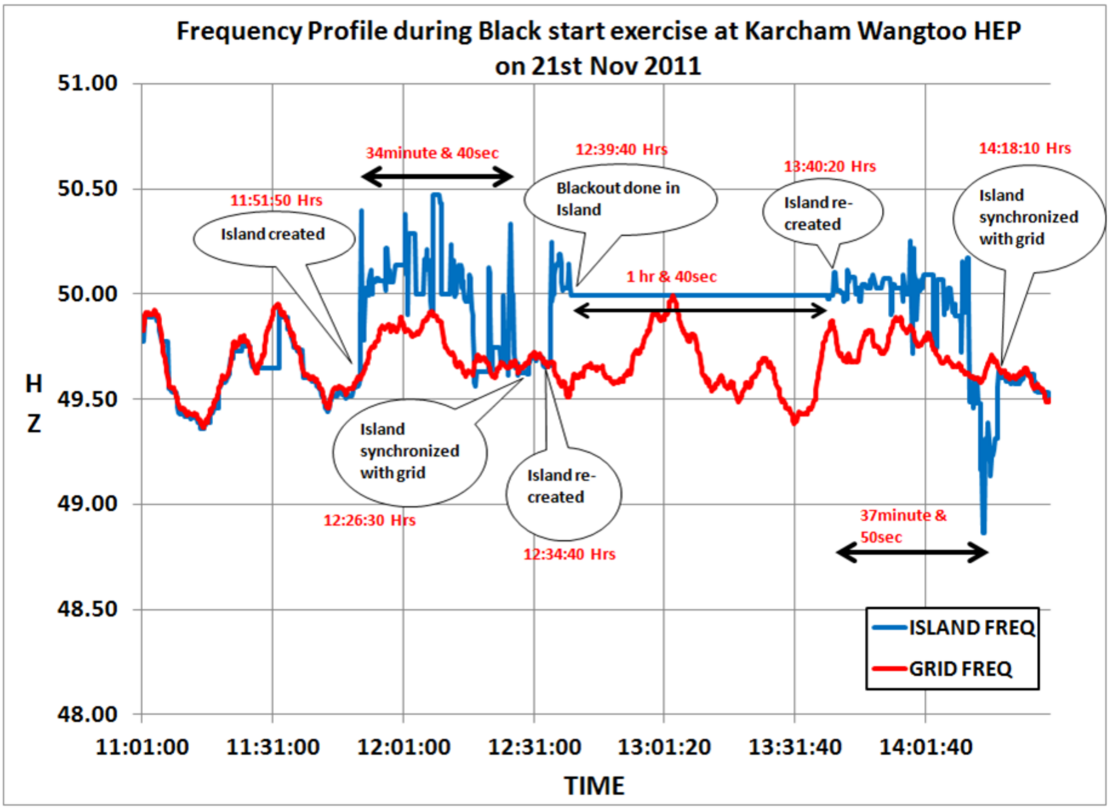
a) Observations during the exercise.

Karcham Wangtoo HEP Black Start Switching Diagram



10.3.2. Details & learning from Mock Exercise

1. This exercise involved creation of island with one unit of Karcham HEP, 400kV Karcham-NJPC ckt-1, 400kV NJPC-Abdullapur ckt-1, and with of load at 220/66kV Jorian substation(HVPNL) substation.
2. After observing island operation for 10-15 minutes, the island was synchronized with grid at Karcham Wangtoo HEP.
3. The island was then re-created and collapsed creating a blackout in the subsystem.
4. The subsystem was build up by self start of one unit at Karcham Wangtoo HEP, charging of one dead 400 kV bus at Karcham Wangtoo HEP, charging of 400 kV Karcham-NJPC ckt-1, charging of 400 kV NJPC-Abdullapur ckt-1 at 400kV Jhakri, charging of 400/220kV ICT-1 & 220kV Bus at Abdullapur(P.G), charging of 220kV Abdullapur(P.G)-Jorian ckt-1 & 2, load at 220/66 kV Jorian Substation.
5. The Islanded operation of the Karcham Wangtoo HEP unit with approx. 30 to 40 MW load at 220/66kV load at Jorian Substation(HVPNL) was observed followed by synchronising of this islanded unit at 400 kV Abdullapur (POWERGRID) substation.



10.4 AD Hydro HEP Black Start Exercise

10.4.1. Procedure

In order to facilitate the mock black start exercise of AD Hydro Power house following switching operation is being suggested at AD Hydro, 400/220 kV Nalagarh (POWERGRID), 220/66 kV Nangal (HPSEB) & 66kV Nalagarh substation(HPSEB). During this exercise the supply at 66 kV Nalagarh (HPSEB) will be affected.

The following preliminary preparations are to be done pr ior to the start of mock exercise i.e., before 10:30 A.M.

1. **Preparation**

   AD Hydro Power Station

   a. Check the preparedness to start one hy dro unit using auxiliary supply from the DG set.
   b. Check the possibility to charge a dead 220 KV bus with the black start unit. Interlocks, if any, in the SCADA system might need to be modified in case it inhibits this activity.
   c. Check the necessary settings to smoothly vary the excitation of the black-start unit over the entire range of the generator capability curve so that the 220 KV bus voltages can be smoothly varied.
   d. Settings of the low forward power relay/reverse power relay installed on the generating units and manufacturer's recommendations for this relay settings, if any, during black-start process.
   e. Ability to vary the governor droop setting so as to accommodate block load additions without any problem.
   f. Ability to vary the frequency of the islanded system over a large range from 48.5 Hz- 50.5 Hz.
   g. The check synchronizing relay settings at AD Hydro HEP available for generating units, lines and 220 kV bus coupler.
   h. Manpower to be deputed for carrying out exercise & witnessing the exercise for learning.

   400/220kV Nalagarh (PG) Substation

   a. Checking the healthiness of synchronizing trolley.
   b. Checking the healthiness of breakers/ isolators in 220kV switchyard in-order to carry out desired switching operations.
   c. Manpower to be deput ed for carrying out exercise & witnessing the exercise for learning.

   220/66kV Nangal Substation (HPSEB)

   a. Checking the healthiness of isolators & breakers of 220kV & 66kV bus in-order to carry out desired switching operations.
   b. The island formed by 220/66kV transformers should have load of around 30-40MW.
   d. Checking the healthiness of isolators & breakers of 220kV & 66kV bus in-order to carry out desired switching operations.
   c. Manpower to be deput ed for carrying out exercise & witnessing the exercise for learning.

66kV Nalagarh Substation (HPSEB)

a. Open 66kV Nalagarh-Baddi ckt-1 & 2. This is required so that there is no feeding from Baddi Substation during formation of island.
b. Checking the healthiness of isolators & breakers of 66kV bus in-order to carry out desired switching operations.
c. The island formed should have load of around 30-40MW. Hence the loading of 66/33kV & 66/11kV transformers at 66kV Nalagarh substation may be kept accordingly.
d. Manpower to be deputed for carrying out exercise & witnessing the exercise for learning.

The Mock exercise would be carried out in co-ordination with NRLDC & SLDC, Shimla(HPSEB), AD Hydro, CPCC Jammu & 400/220kV Nalagarh (P.G) Substation, 220kV Nangal Substation, 66kV Nalagarh(HPSEB) Substation. Manpower to be deputed at all above locations for carrying out the exercise and witnessing for learning.

2. **The entire exercise would be conducted in the following four stages. The exercise would start at 10:30 hrs**

Stage-1: Initial Switching operations

Objective is to carry out switching operations so that a subsystem is created with identified load of 66kV Nalagarh (HPSEB) Substation being fed by one unit of AD Hydro through 220kV AD Hydro-Nalagarh line, 220kV Nalagarh-Nangal ckt-1, Transformer-1 at 220/66kV Nangal, 66kV Nangal-Nalagarh ckt-1&2.

Note: ***Take operational code from NRLDC to start switching operation for mock exercise.***

a. At 66 kV Nalagarh Substation (HPSEB)
At 66kV switchyard at Nalagarh

1. Manually open 66kV Nalagarh-Baddi ckt-1 & 2.
2. Adjust the loading on 66/33kV & 66/11kV transformers so that the total loading is around 40 MW.

b. At 220/66 kV Nangal Substation (HPSEB)
At 66kV switchyard at Nangal

1. Keep 66kV Nangal-Nalagarh ckt-1&2, 220/66kV Transformer-1 on 66 kV Bus-1.
2. Keep 66kV Nangal-Ambuja cement & 220/66kV Transformer-2 on 66 kV Bus-2
3. Open the 66kV Bus coupler

Sl. No.	66kV Bus-1 at Nangal	66 kV Bus-2 at Nangal
1.	66kV Nangal-Nalagarh ckt-1&2, 220/66kV Transformer-1	66kV Nangal-Ambuja cement & 220/66kV Transformer-2

c. At 220 kV switchyard at Nangal

1. Keep 220kV Nalagarh(P.G)-Nangal ckt-1, 220/66kV Transformer-1 on 220kV Bus-1.
2. Keep 220kV Nalagarh(P.G)-Nangal ckt-2, 220/66kV Transformer-2 on 220kV Bus-2.
3. Open the 220kV Bus coupler

Sl. No.	66kV Bus-1 at Nangal	66 kV Bus-2 at Nangal
1.	220kV Nalagarh(P.G)-Nangal ckt-1, 220/66kV Transformer-1	220kV Nalagarh(P.G)-Nangal ckt-2, 220/66kV Transformer-2

Note: SLDC, Shimla to ensure that the loading is under control.

d. At 400/220 kV Nalagarh (POWERGRID)
At 220kV switchyard at Nalagarh (PG)

1. Keep 220kV Ad Hydro-Nalagarh, 220kV Nalagarh-Nangal ckt-1 on 220kV Bus-1
2. Keep ICT-1, ICT-2, 220kV Nalagarh-Chaur line, 220 kV Nalagarh-Mohali ckt-1&2, 220kV Nalagarh-Chandigarh ckt-1&2 on 220kV Bus-2.
3. Open 220 kV Bus Coupler.

Sl. No.	220 kV Bus-1 at Nalagarh (P.G)	220 kV Bus-2 at Nalagarh (P.G)
1.	220kV Ad Hydro-Nalagarh, 220kV Nalagarh-Nangal ckt-1	ICT-1, ICT-2, 220kV Nalagarh-Chaur, 220 kV Nalagarh-Mohali ckt-1&2, 220kV Nalagarh-Chandigarh ckt-1&2

e. AD Hydro Power Station
At 220kV switchyard at AD Hydro

1. The feeders would be re-arranged such that 220 kV Ad Hydro-Nalagarh line, unit to be self started are connected to Bus-1.
2. A Remaining Units along with 220kV Ad Hydro-Chaur line would be connected to Bus-2.
3. **Keep bus coupler in <u>closed position</u> at AD Hydro.**

Sl. No.	220 kV Bus-1 at AD Hydro	220 kV Bus-2 at AD Hydro
1.	220 kV Ad Hydro-Nalagarh line, unit#1(presumed to be black started)	Remaining Units along with 220kV Ad Hydro-Chaur line

Note 1: Unit#1 is presumed to be black-started. However, AD hydro may decide upon the unit which will be black-started during the black-start exercise.

Note 2: It may be ens ured that isolators are also opened af ter opening the breaker to avoid very high voltages across switched off breakers at all locations.

Stage-2: Testing of AD Hydro unit for islanded operation and checking the synchronizing capability at AD Hydro HEP

a. The subsystem with 66kV Nalagarh load and Unit#1 (intended unit for black-start) at AD Hydro is coupled with the grid through 220 kV bus coupler at AD Hydro.
b. Regulate the generation at AD Hydro unit#1 (intended unit for black-start) in-order to maintain minimum power flow through 220 kV bus coupler at AD Hydro.
c. Create Island by opening the 220 kV bus coupler at 220 kV AD Hydro **after taking a code from NRLDC** and allow the subsystem to operate in islanded mode for at least 15 minutes. **AD Hydro unit in the subsystem would have to be in free governor mode and AVR on AUTO mode**.
d. AD Hydro HEP has to regulate the frequency of the subsystem and operate it at 50 Hz and 50.5 Hz for 5 minutes each.
e. Now synchronize the subsystem to the grid through the 220 kV bus coupler at AD Hydro without interrupting the load at 66kV Nalagarh substation.

Stage-3: Mock black start exercise

<u>Creating Blackout at 66kV Nalagarh</u>

a. At 220 kV AD Hydro

1. Open the 220 kV bus coupler at AD Hydro. This would re-create the island.
2. **Take operation code from NRLDC** and Trip Unit#1 (intended unit for black-start) breaker. This would interrupt the power supply to island formed with load of 66 kV Nalagarh and de-energize 220kV AD Hydro-Nalagarh line, 220kV Nalagarh-Nangal ckt-1, Transformer-1 at 220 kV Nangal creating blackout in subsystem (island).
3. Open breaker of 220 kV AD Hydro-Nalagarh line.

b. At 400/220kV Nalagarh(P.G)

1. Open breaker of 220kV AD Hydro-Nalagarh line & 220 k V Nalagarh-Nangal ckt-1.

c. At 220/66kV Nangal(HPSEB) substation

1. Open breaker of 220kV Nalagarh(P.G)-Nangal ck-1, 220/66kV Transformer-1, 66kV Nangal-Nalagarh ckt-1&2.

d. At 66kV Nalagarh(HPSEB) substation

1. Open breakers of 66/33kV & 66/11 transformers, 33kV & 11kV feeders which were kept in service during islanded operation.

<u>Black-starting of Unit at AD Hydro HEP</u>

a. At AD Hydro Power station

1. Now self start unit#1(intended unit for black-start) at AD Hydro. Ensure that auxiliary supply is taken from local DG set (as would be done during a blackout). Charge the dead 220 kV Bus–1 at AD Hydro through this unit. U nit#1 (intended unit for black-start)

would be on free governor mode of operation. AVR may be kept on AUTO mode.

2. Maintain bus voltage around 215 kV by varying the excitation i.e., the AVR set point to be kept accordingly.
3. Charge the 220 kV AD Hydro-Nalagarh line after taking clearance from Nalagarh(P.G) and code from NRLDC.

b. At 400/220 kV Nalagarh (POWERGRID)

1. Observe line voltage on 220kV AD Hydro-Nalagarh line. The open end line voltage should not be more than 220 kV. If voltage is high, then ask AD Hydro engineers to adjust excitation of Unit to lower the open end voltage at 220kV Nalagarh(P.G) to desired level. If the voltage is within desired limits, close breaker of 220 kV Ad Hydro-Nalgarh line and 220kV Nalagarh-Nangal ckt-1 in coordination with AD Hydro and 220kV Nangal substation.
2. The 220kV bus coupler is to be kept open.

c. At 220/66 kV Nangal Substation

1. After line voltage is available on 220kV Nalagarh-Nangal Ckt-1, charge 220 kV bus-1 at Nangal by closing breaker of 220 kV Nalagarh-Nangal ckt-1.
2. Charge 220/66kV transformer-1 which will energise 66kV bus.
3. Close the breaker of 66kV Nangal-Nalagarh ckt-1&2.
4. The 220kV & 66kV Bus coupler at Nangal substation should be kept open.

d. At 66 kV Nalagarh

1. After line voltage is available, charge 66 kV bus-1 by closing breaker of 66kV Nangal-Nalagarh ckt-1&2
2. Charge 66/33kV & 66/11kV transformers. This will in-turn energise the 33kV & 11kV Bus at Nalagarh.
3. Connect the 33kV & 66kV radial load gradually say in steps of 10 MW at Nalagarh on clearance from SLDC, Shimla. SLDC, Shimla may co-ordinate with 66kV Nalagarh during restoration of load.
4. The load should be in the range of 30-40MW.
5. Nangal substation would ensure that the breakers of 66kV Nalagarh-Baddi ckt-1&2 are kept open.

Observe islanded operation for about 10 to 15 minutes.

Stage-4: Restoration

a. At 400/220 kV Nalagarh (POWERGRID)

1. **Take operational code from NRLDC** & synchronise the island (subsystem) with the grid at 400/220 Nalagarh (POWERGRID).
2. The synchronization of island with grid can be done through closing of 220kV Bus coupler.
3. AD Hydro unit running in the islanded subsystem would carry out the frequency matching. The Nalagarh(P.G) end operator would ensure that the closing is done when the voltage and frequency of subsystem and main grid are within prescribed synchronization limits.

Note: Close co-ordination is required between 400/220kV Nalagarh(P.G) substation, AD Hydro HEP, 220kV Nangal Substation & 66kV Nalagarh (HPSEB)substation for regulating generation, load & synchronizing.

After synchronisation restore the system back to normal operation by:

a. Close the 220 kV bus coupler at AD Hydro followed by uniform arrangement of feeders on bot h the buses. In case any change in setting of low forward power relay or reverse power relay has been made to facilitate black start, the same may be reversed to the original setting.
b. Uniform arrangement of feeders on bot h the buses at 400/220kV Nalagarh.
c. Closing of 220kV & 66kV Bus coupler at 220kV Nangal substation followed by uniform arrangement of feeders on both the buses.
d. Charging of 66kV Nalagarh-Baddi ckt-1&2 and r estoration of load at 66kV Nalagarh Substation.
e. Normalization of all connection as prior to the start of Mock exercise.

After completion of the mock black start exercise, kindly forward your observation during the exercise.

AD Hydro Power Station

a) Observations during the exercise.
b) Changes done in protection, AVR setting & governor droop settings, modification of interlocks, Low forward power/reverse power setting, check synchronization relay setting, any other modifications done for nock exercise.

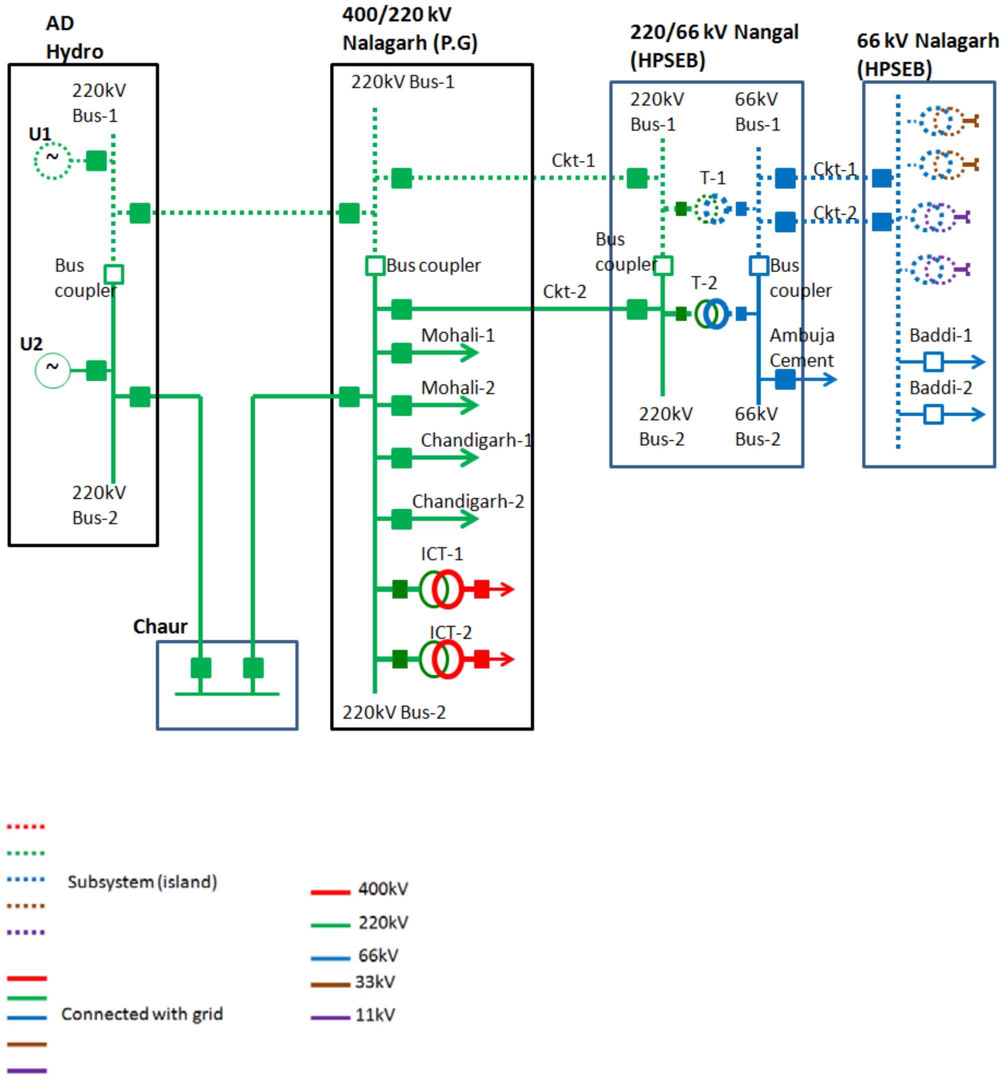
400/220kV Nalagarh POWERGRID

a) Observations during the exercise.
b) Changes done in protection, check synchronization relay setting, any other modifications done for mock exercise.

SLDC, Shimla (HPSEB)

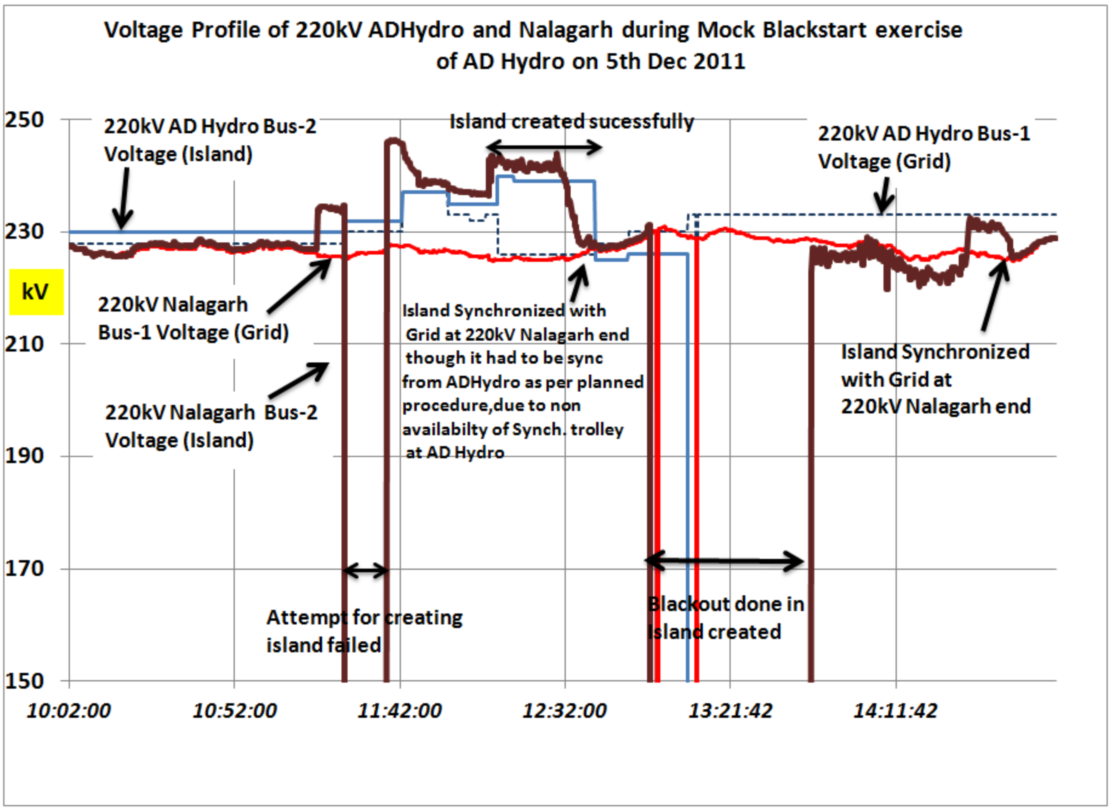
a) Observations during the exercise.

Black Start Switching Diagram of AD Hydro

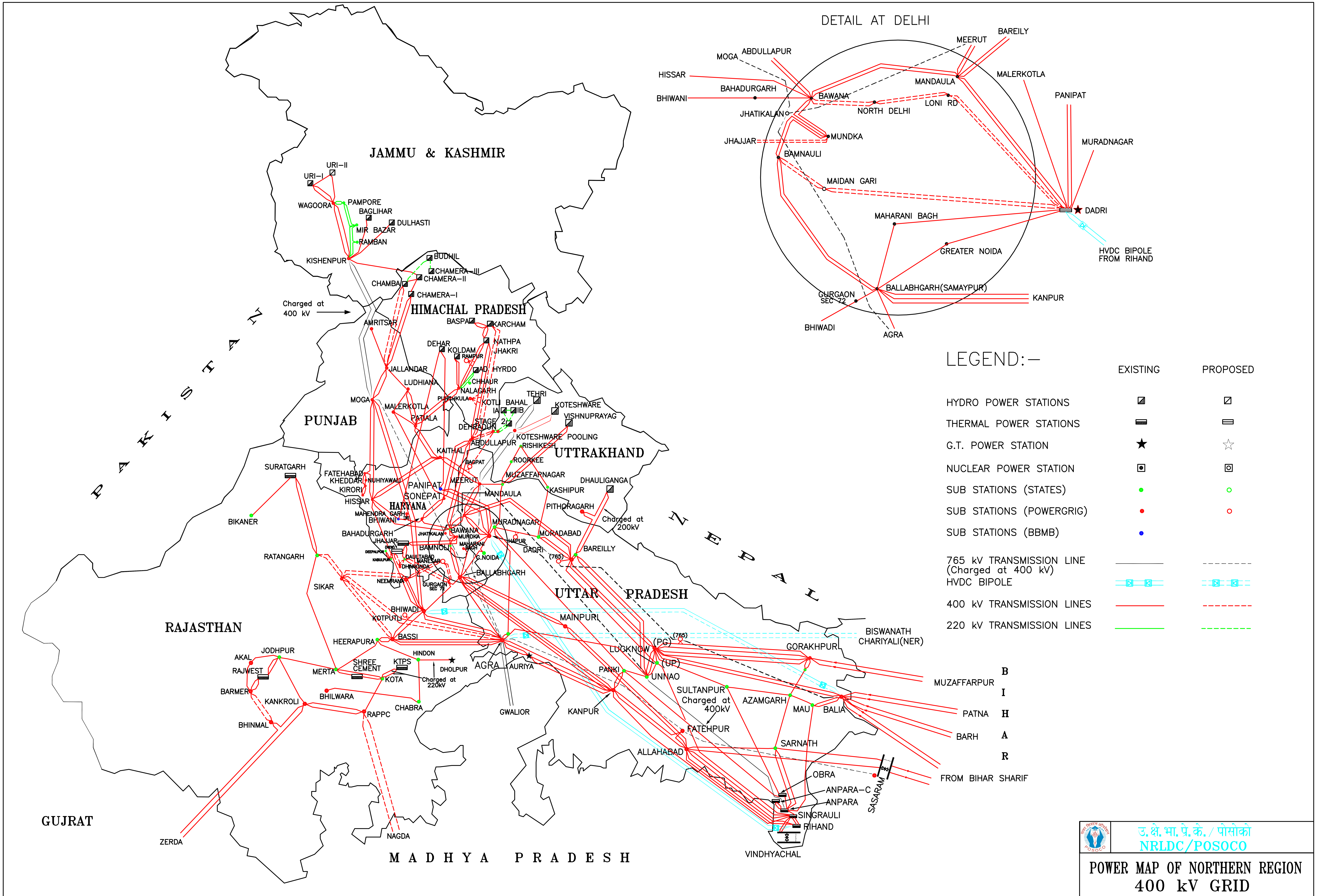


10.4.2. Details & learning from Mock Exercise

1. This exercise involved creation of island with one unit of AD Hydro station, 220kV AD hydro-Nalagarh ckt-1, 220kV Nalagarh-Nangal ckt-1, and with of load at 66kV Nalagarh substation(HPSEB) substation.
2. After observing island operation for 10-15 minutes, the island was synchronized with grid at 400/220kV Nalagarh(P.G)
3. The island was then re-created and collapsed creating a blackout in the subsystem.
4. The subsystem was build up by self start of one unit at AD Hydro, charging of one dead 220 kV bus at AD Hydro HEP, charging of 220kV AD Hydr-Nalagarh(P.G) ckt-1, charging of 220kV Nalagarh(P.G)-Nangal ckt-1 , charging of 220/66 transformer, T1 at 220/66kV Nangal substation, charging of 66kV Nangal-Nalagarh(HPSEB) ckt-1, charging of load at 220/66 kV Nalagarh (HPSEB) Substation.
5. The Islanded operation of the Karcham Wangtoo HEP unit with approx. 30 to 40 MW load at 220/66kV load at Jorian Substation(HVPNL) was observed followed by synchronising of this islanded unit at 400 kV Abdullapur (POWERGRID) substation.



Annexure



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POWER MAP OF NORTHERN REGION 400 kV GRID

GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY	SCALE : NOT TO SCALE	DRN. BY Ramjit	DECEMBER 2011	11

Annexure-II Reactive action plan

* In conjunction with shunt capacitor where necessary

Source: Reactive Power Control in Electric System, Edited by Timothy J. E. Miller

Problem, Application or Purpose		Existing Equipment or Method									Special Purpose Compensating Equipment							
		Increase Transmission Voltage	Increase number of parallel lines	Transformer Tap Changing	Slow AVR Control	Fast AVR Control	Fast Turbine Valving	Rapid line switching operations	Reclosing of Circuit Breakers	Breaking Resistors	Shunt Reactor	Series Reactor	Series Capacitor	Synchronous Condenser	Polyphase Saturated Reactor *	Thyristor Controlled Reactor *	Thyristor Switched Capacitor	Fault Current (S/C) Limiter Coupling
Fundamental Requirement #1	Improve Steady State Stability	■	■		■	■					■		■	■	■	■		
	Improve Dynamic Stability					■								■		■	■	
	Improve Transient Stability	■				■	■	■	■	■			■	■	■	■		
Fundamental Requirement #2	Limit rapid voltage decline					■		■	■					■	■	■		
	Limit slow voltage decline			■	■									■	■	■	■	
	Limit rapid voltage increase					■		■	■		■			■	■	■		
	Limit slow voltage increase			■	■						■			■	■	■	■	
	Limit fast wave front over voltage due to lightning, switching etc.										■			■	■	■		
Other Requirements	Reactive power support at DC converter Terminal.													■	■	■	■	
	Increase Short Circuit Level												■	■				
	Decrease Short Circuit Level											■						■

Annexure-III

Network Diagram and Power-Maps

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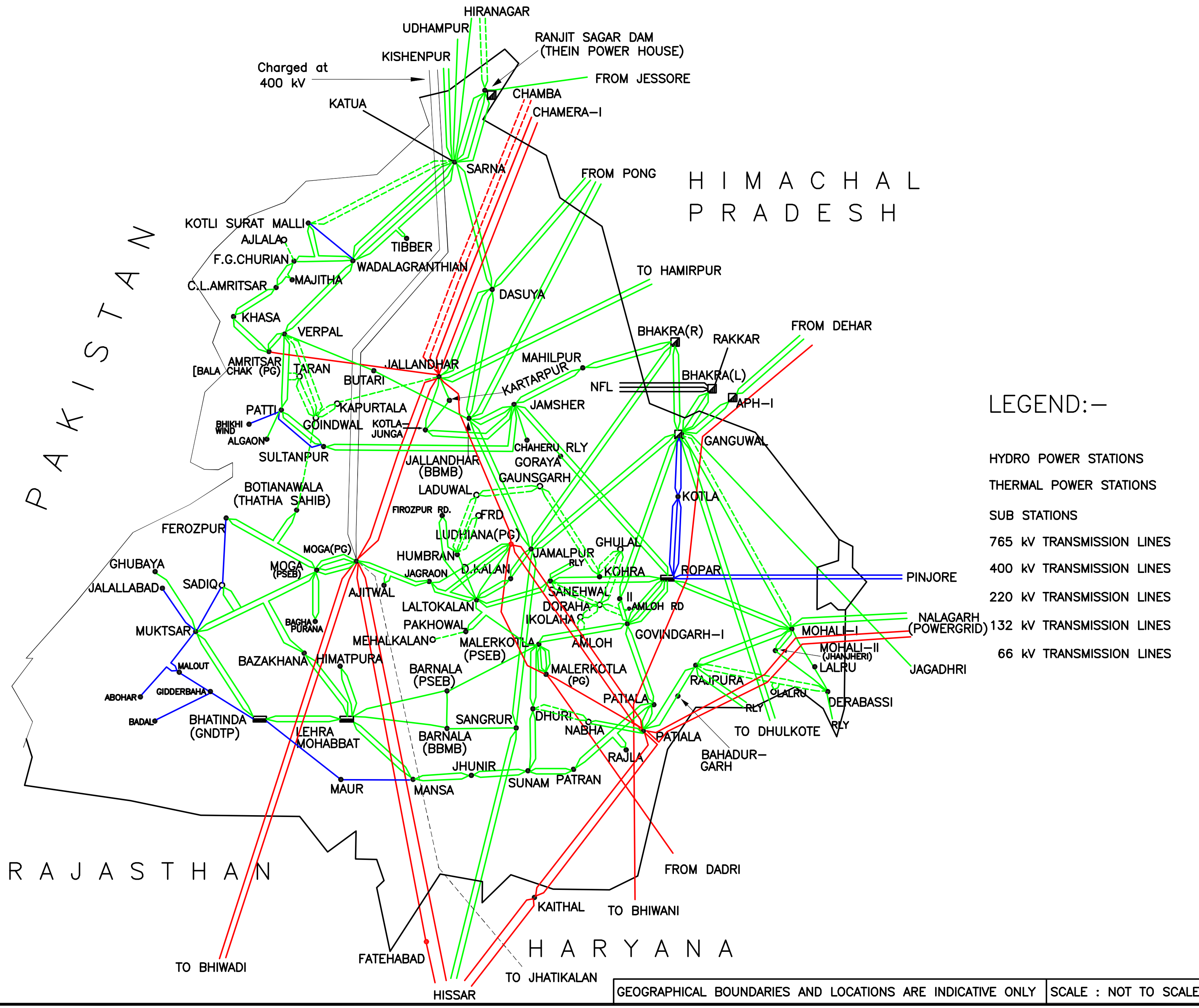
पावर मैप पंजाब
POWER MAP OF PUNJAB



GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY	SCALE : NOT TO SCALE	DRN. BY Ramjit	DECEMBER 2011	2

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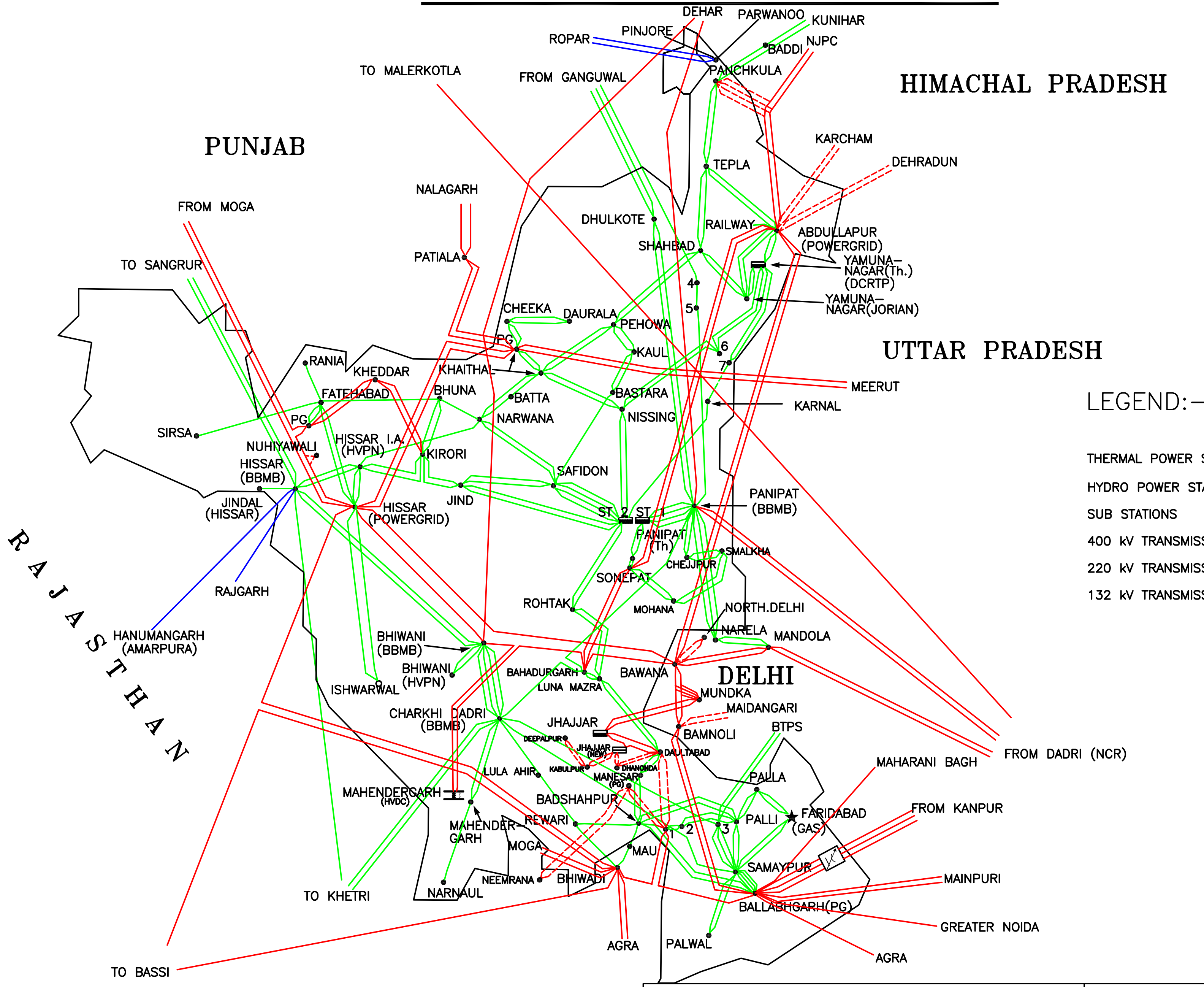
पावर मैप पंजाब
POWER MAP OF PUNJAB

पावर मैप हरियाणा
POWER MAP OF HARYANA



LEGEND:-

	EXISTING	PROPOSED
THERMAL POWER STATIONS	▬	▭
HYDRO POWER STATIONS	★	☆
SUB STATIONS	•	∘
400 kV TRANSMISSION LINES	red solid line	red dashed line
220 kV TRANSMISSION LINES	green solid line	green dashed line
132 kV TRANSMISSION LINES	blue solid line	blue dashed line

1 GURGAON SECTOR 72
2 GURGAON SECTOR 52
3 BALLABHGARH (BBMB)
4 KHERA (JAGADHRI)
5 KURKSHETRA(PIPLI)
6 SALIMPUR
7 NILOKHERI

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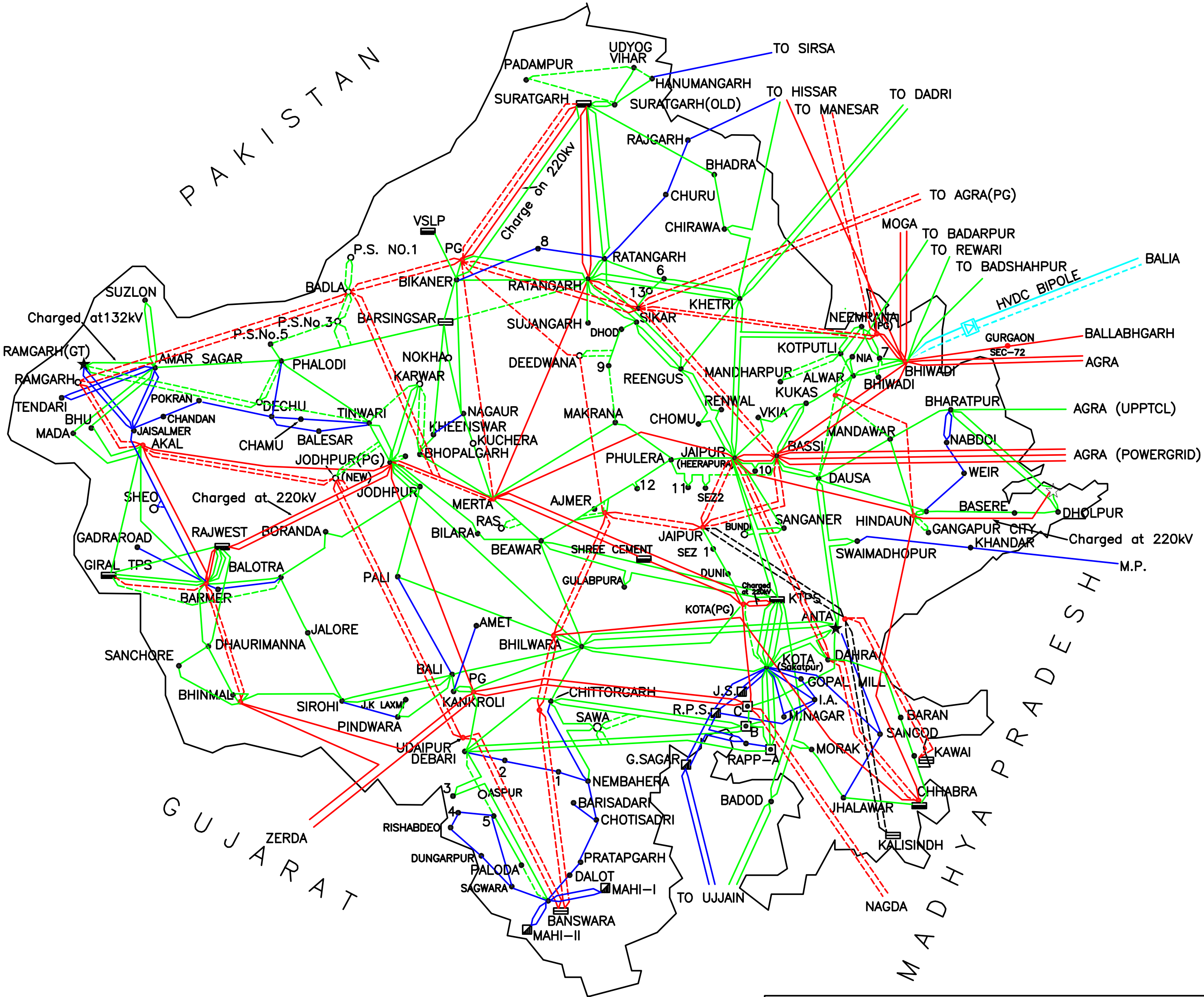
पावर मैप हरियाणा
POWER MAP OF HARYANA

GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY	SCALE : NOT TO SCALE	DRN. BY Ramjit	DECEMBER 2011	3

पावर मैप राजस्थान
POWER MAP OF RAJASTHAN



LEGEND:–

	EXISTING	PROPOSED
HYDRO POWER STATIONS	◪	◻
THERMAL POWER STATIONS	▬	▭
G.T. POWER STATION	★	☆
NUCLEAR POWER STATION	◙	◙
SUB STATIONS	•	○
HVDC BIPOLE		- - -
400 kV TRANSMISSION LINES	——— (red)	- - - (red)
220 kV TRANSMISSION LINES	——— (green)	- - - (green)
132 kV TRANSMISSION LINES	——— (blue)	- - - (blue)

1	MANGLABAD	9	KUCHAMAN CITY
2	BHINDER	10	IGN J.PURA
3	PRATAPGARH	11	BAGRU
4	JAWAHARMINES	12	KISHANGARH
5	SALUMBER	13	PIPRALI
6	JHUNJHUNU		
7	KHUSHKHERA		
8	SRIDUNGARGARH		

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पावर मैप राजस्थान
POWER MAP OF RAJASTHAN

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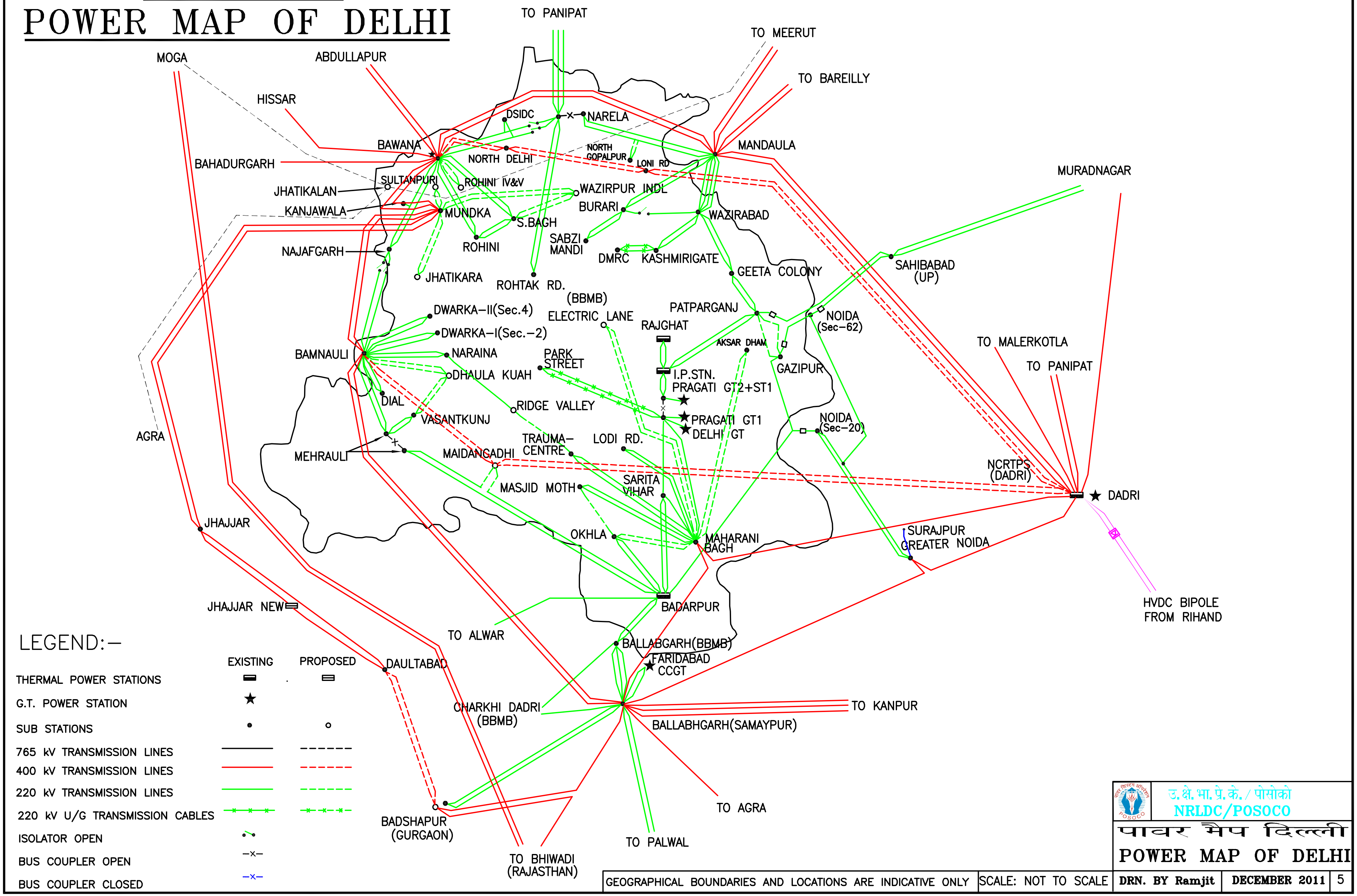
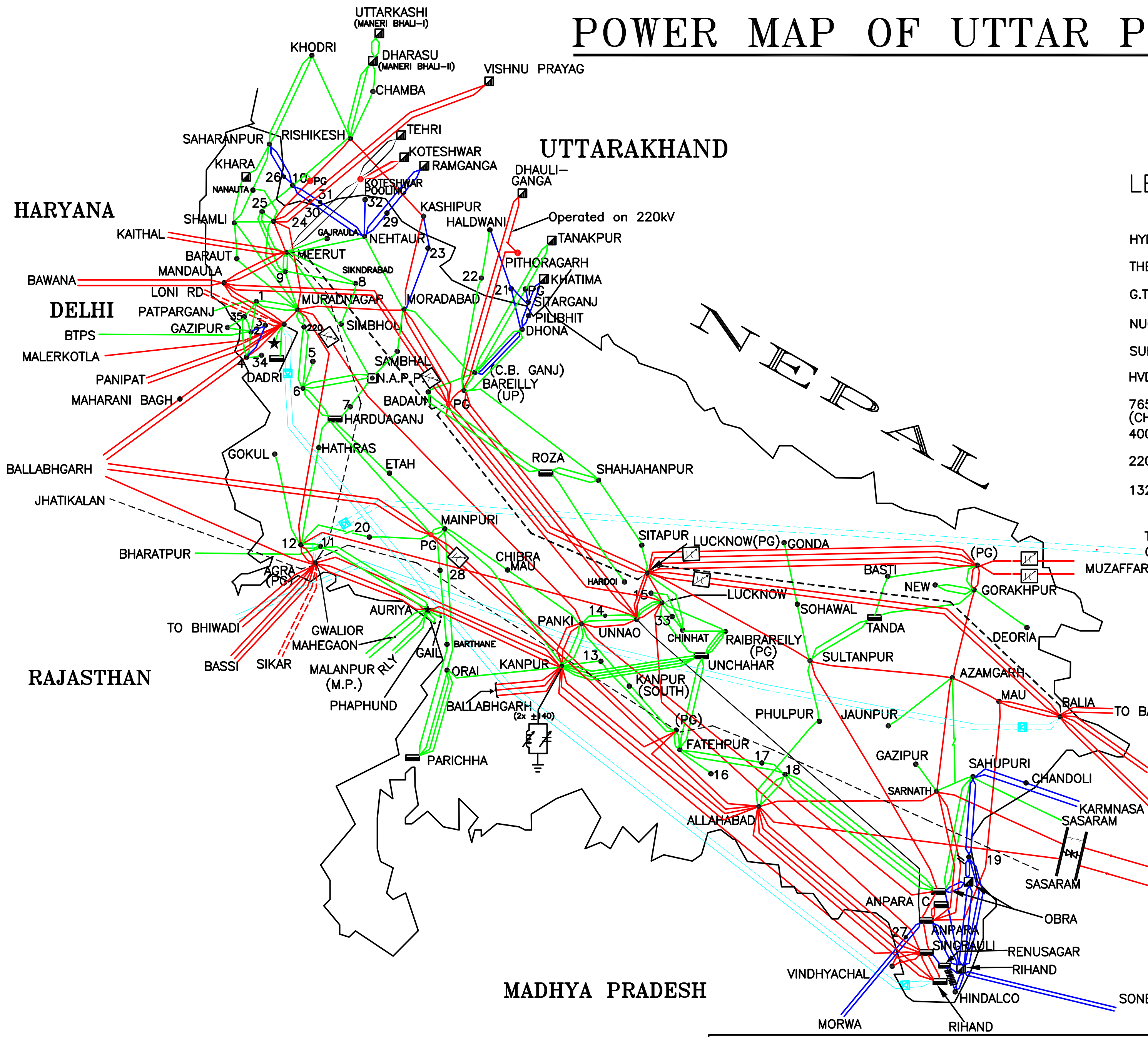
पावर मैप दिल्ली
POWER MAP OF DELHI



पावर मैप उत्तर प्रदेश

POWER MAP OF UTTAR PRADESH



LEGEND:–

	EXISTING	PROPOSED
HYDRO POWER STATIONS		
THERMAL POWER STATIONS		
G.T. POWER STATION	★	☆
NUCLEAR POWER STATION		
SUB STATIONS	•	∘
HVDC BIPOLE		
765 kV TRANSMISSION LINES (CHARGED AT 400kV)		
400 kV TRANSMISSION LINES		
220 kV TRANSMISSION LINES		
132 kV TRANSMISSION LINES		

1	SAHIBABAD	16	BANDA
2	NOIDA–20	17	ALLAHABAD CANTT.
3	SURAJPUR	18	REWA ROAD
4	GRATER NOIDA	19	ROBERTSGANJ
5	JAHANGIRABAD	20	FIROZABAD
6	KHURJA	21	KICHA
7	ATRAULI	22	PANTNAGAR
8	SHTABADI NAGAR	23	THAKURDWARA
9	MODI PURAM	24	MUZAFARNAGAR
10	ROORKEE	25	NARA
11	AGRA (SIKANDRA)	26	BHAGWANPUR
12	AGRA(UPPCL)	27	BINA
13	NAUBASTA	28	SAFAI
14	RPH	29	DHAMPUR
15	HARDOI ROAD	30	MANGLORE
		31	LAKSAR
		32	NAZIBABAD
		33	GOMTINAGAR
		34	NOIDA–129
		35	NOIDA–62

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POWER MAP OF UTTAR PRADESH

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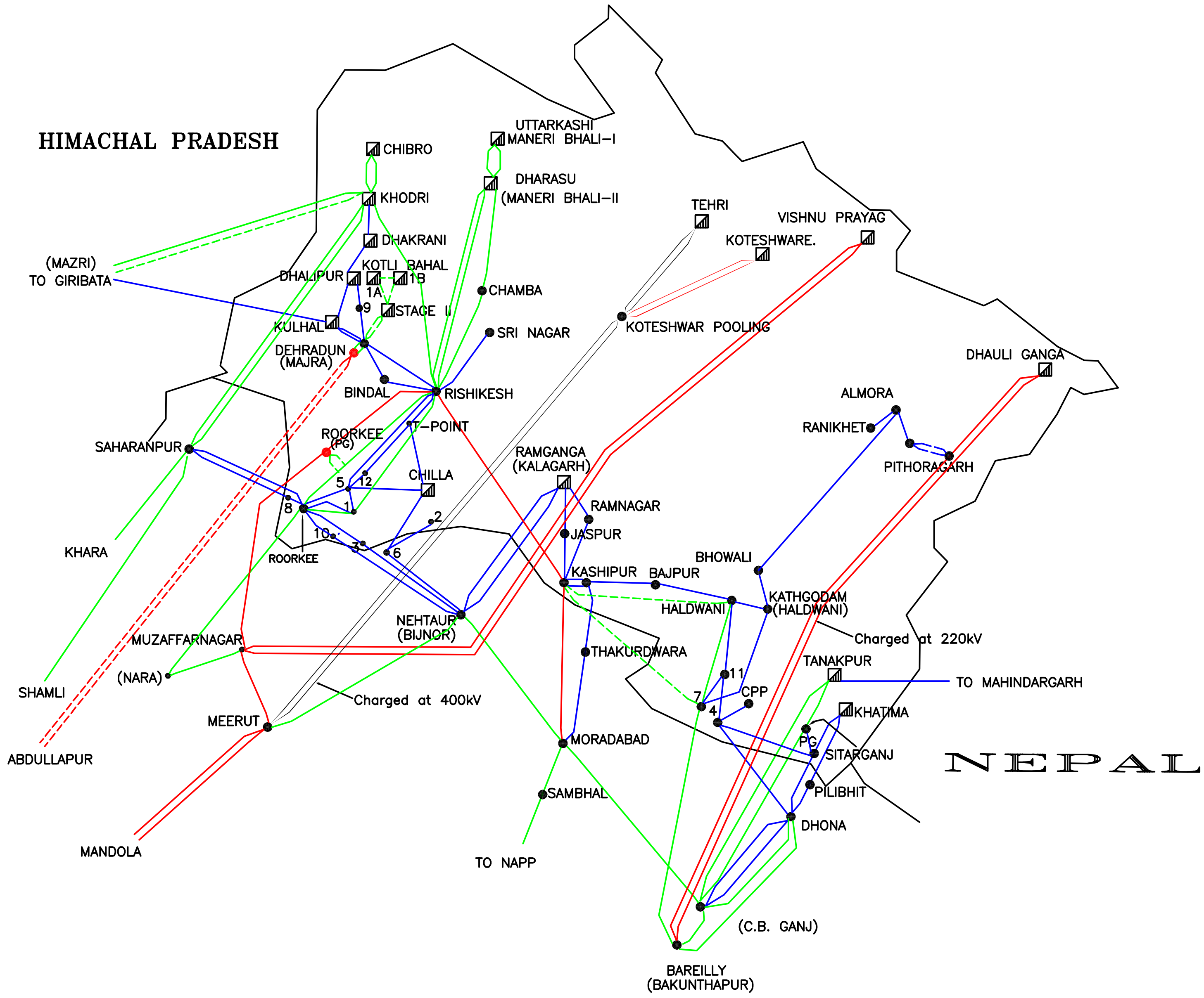
पावर मैप उत्तराखण्ड
POWER MAP OF UTTARAKHAND



LEGEND:–

	EXISTING	PROPOSED
HYDRO POWER STATIONS		
SUB STATIONS		
765 kV TRANSMISSION LINES (CHARGED AT 400kV)		
400 kV TRANSMISSION LINES		
220 kV TRANSMISSION LINES		
132 kV TRANSMISSION LINES		

1	HARDWAR (SIDKUL)	8	BHAGWANPUR
2	KOTDWAR	9	PURKUL
3	MANGLORE	10	LAKSAR
4	KICHA	11	RUDRAPUR
5	JAWALAPUR	12	BHUPATWALA
6	NAZIBABAD		
7	PANT NAGAR		

GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY | SCALE : NOT TO SCALE

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POWER MAP OF UTTARAKHAND
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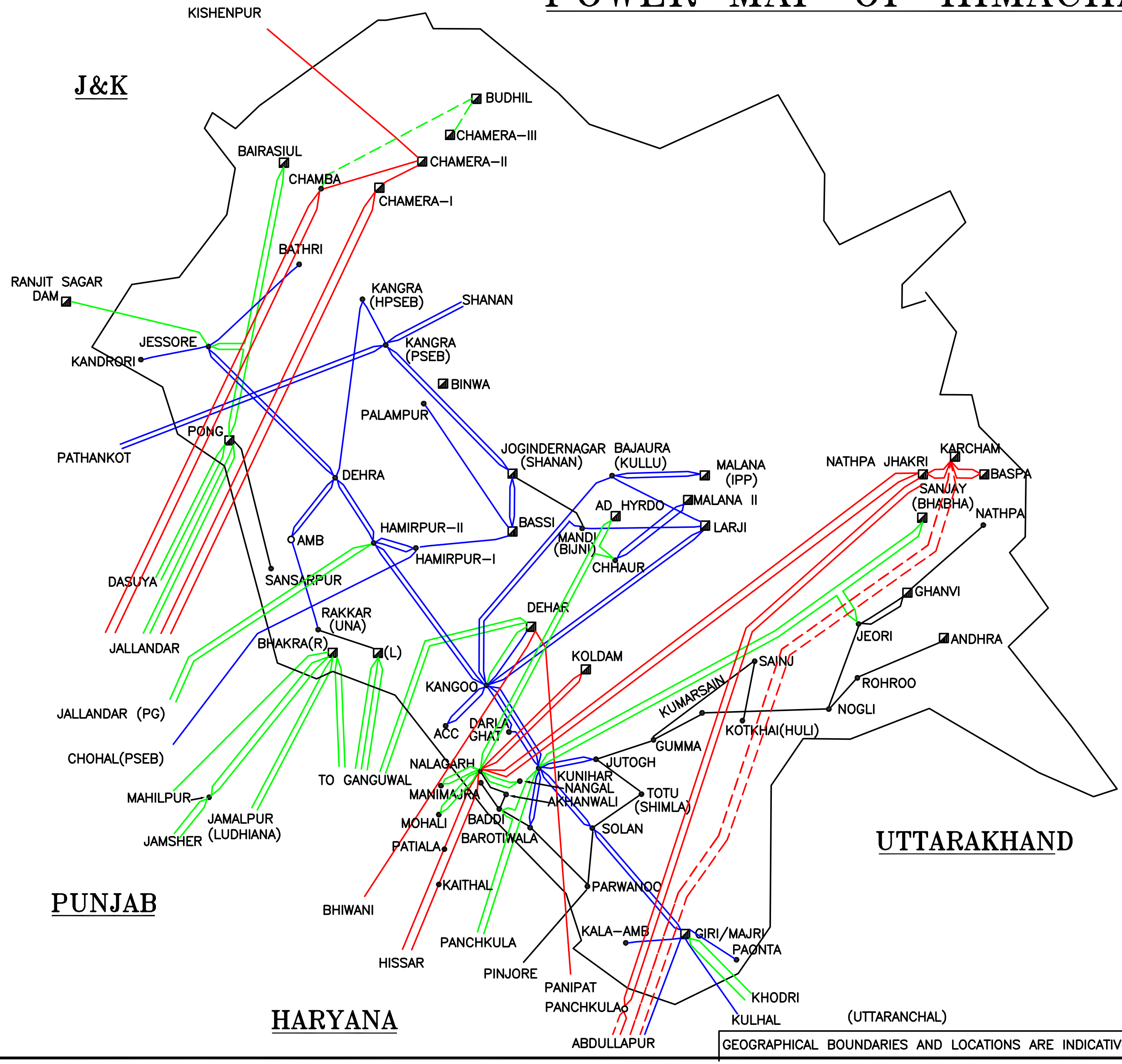
पावर मैप हिमाचल प्रदेश

POWER MAP OF HIMACHAL PRADESH



LEGEND:–

	EXISTING	PROPOSED
HYDRO POWER STATIONS	◪	◪
SUB STATIONS	•	∘
400 kV TRANSMISSION LINES	red solid line	red dashed line
220 kV TRANSMISSION LINES	green solid line	green dashed line
132 kV TRANSMISSION LINES	blue solid line	blue dashed line
66 kV TRANSMISSION LINES	black solid line	black dashed line

GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY

SCALE : NOT TO SCALE

उ. क्षे. भा. प्रे. के. / पोसोको
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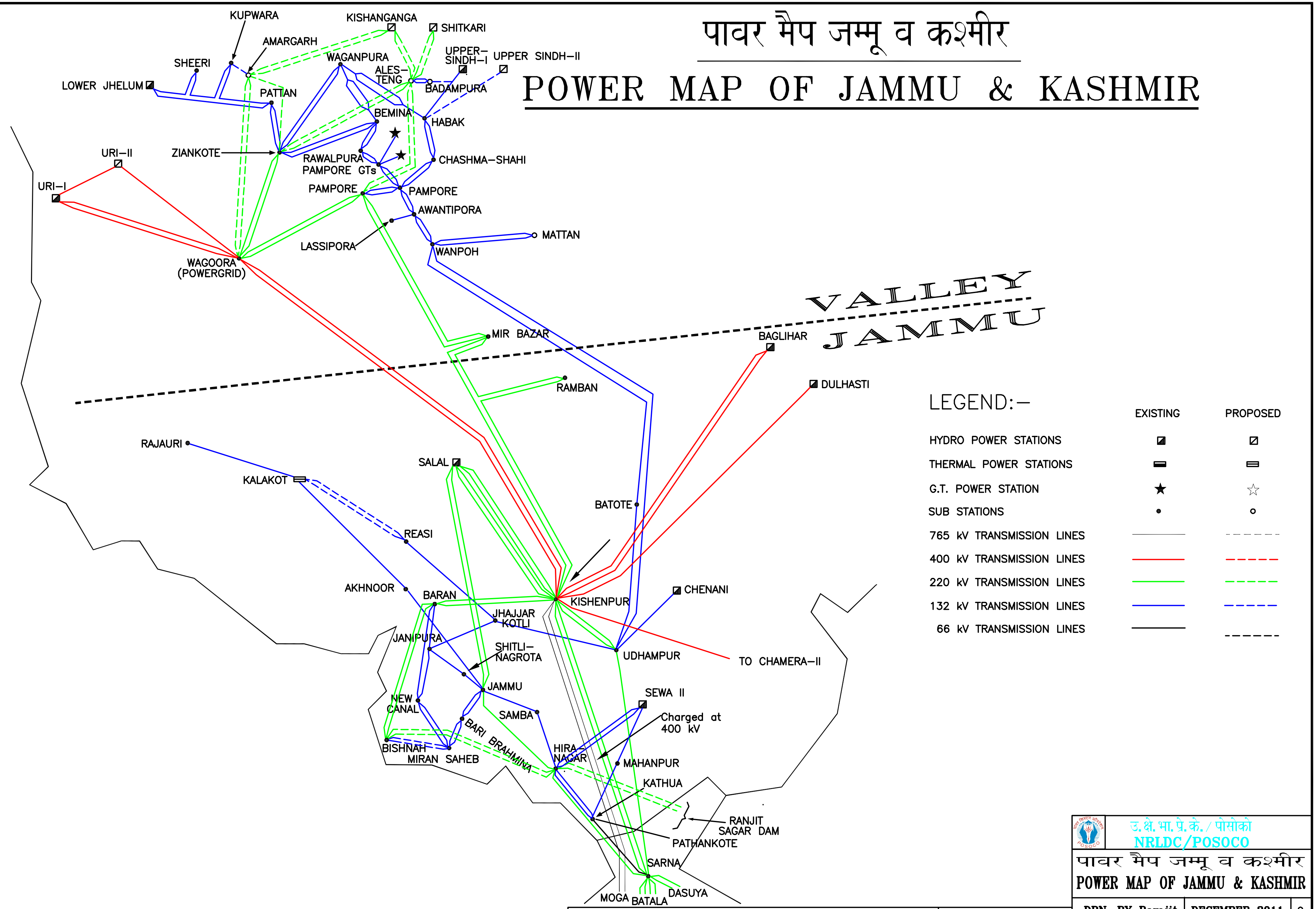
पावर मैप हिमाचल प्रदेश
POWER MAP OF HIMACHAL PRADESH

DRN. BY Ramjit	DECEMBER 2011	8

पावर मैप जम्मू व कश्मीर

POWER MAP OF JAMMU & KASHMIR



GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY | SCALE : NOT TO SCALE

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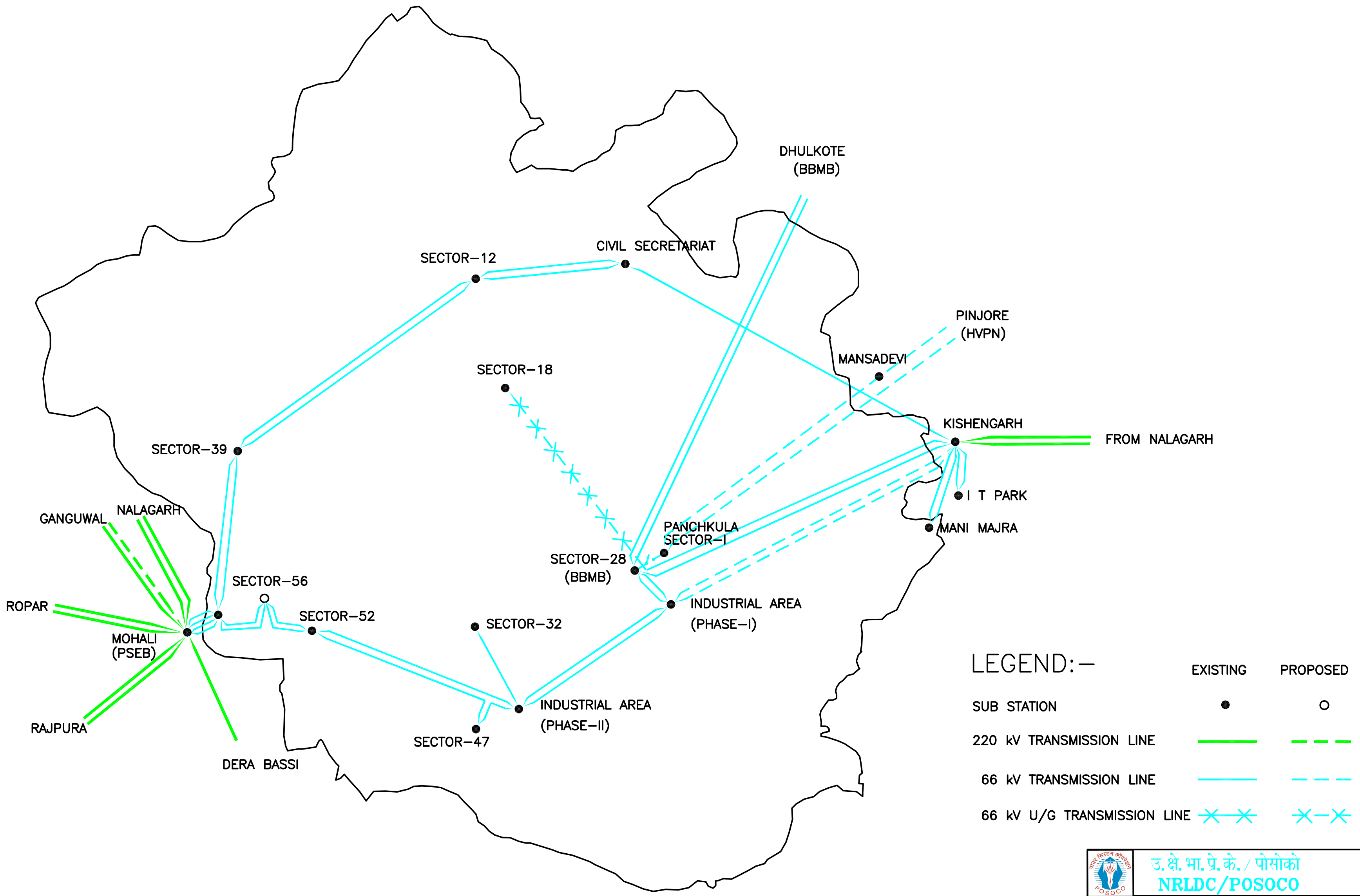
पावर मैप जम्मू व कश्मीर
POWER MAP OF JAMMU & KASHMIR
DRN. BY Ramjit | DECEMBER 2011 | 9

पावर मैप चण्डीगढ़

POWER MAP OF CHANDIGARH



उ.क्षे.भा.प्रे.के. / पोसोको NRLDC/POSOCO				
पावर मैप चण्डीगढ़ POWER MAP OF CHANDIGARH				
GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY	SCALE : NOT TO SCALE	DRN. BY Ramjit	DECEMBER 2011	10

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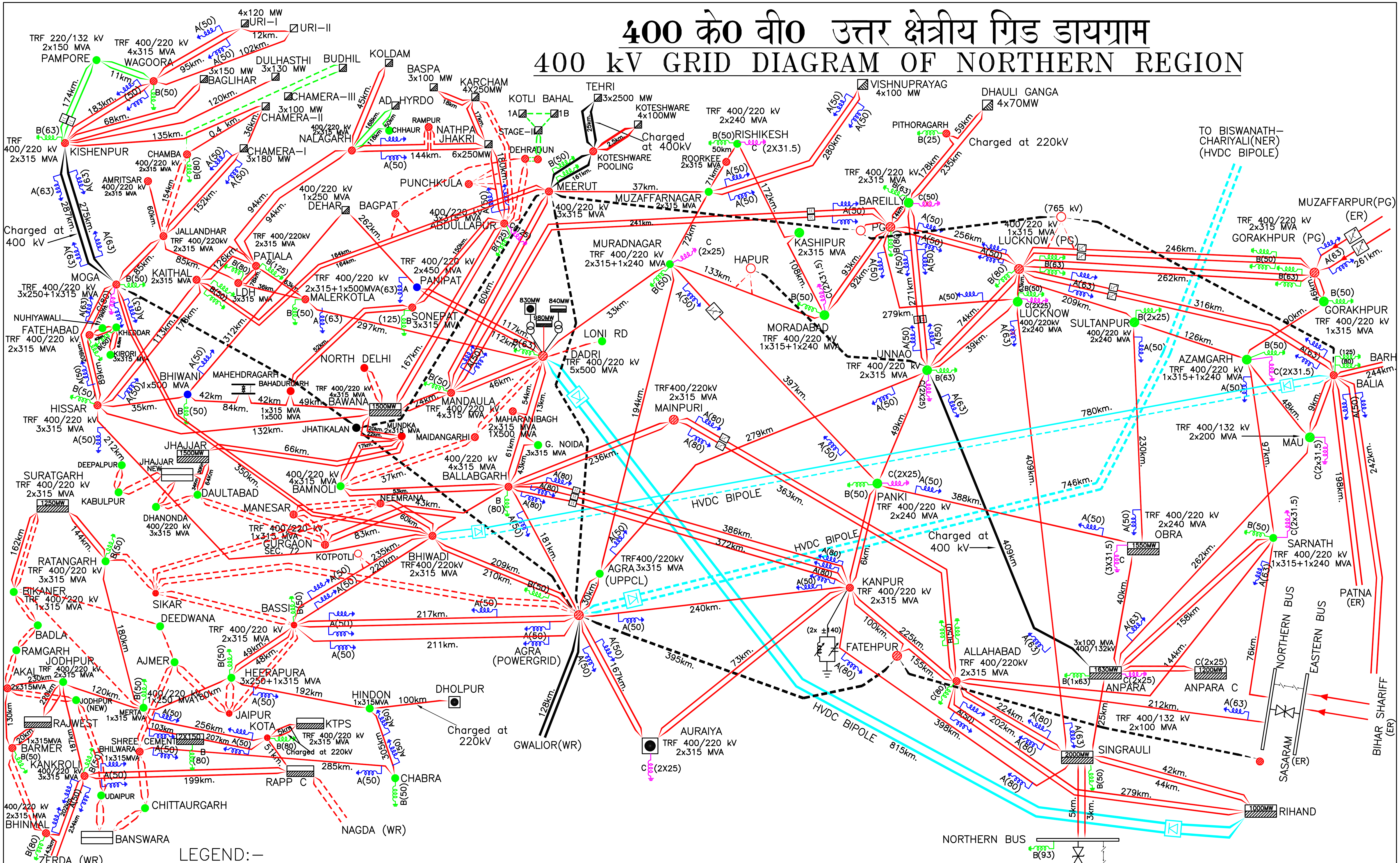
400 केवी उत्तर क्षेत्रीय ग्रिड डायग्राम

400 kV GRID DIAGRAM OF NORTHERN REGION



LEGEND:-

HYDRO	BBMB SUB-STATION	33 kV SWITCHED BUS REACTOR
THERMAL	STATES SUB-STATION	HVDC BACK TO BACK
GAS	SERIES CAPACITOR	STATIC VAR COMPENSATOR
POWERGRID SUB-STATION	400 kV UNSWITCHED LINE REACTOR	FACT
	400 kV SWITCHED BUS/LINE REACTOR	SVC & BUS/LINE REACTOR RATING IN MVAR

765 kV TRANSMISSION LINES
HVDC _ 500 kV LINE
400 kV TRANSMISSION LINES
220 kV TRANSMISSION LINES
PROPOSED/UNDERCONSTRUCTION LINES ARE SHOWN DOTTED

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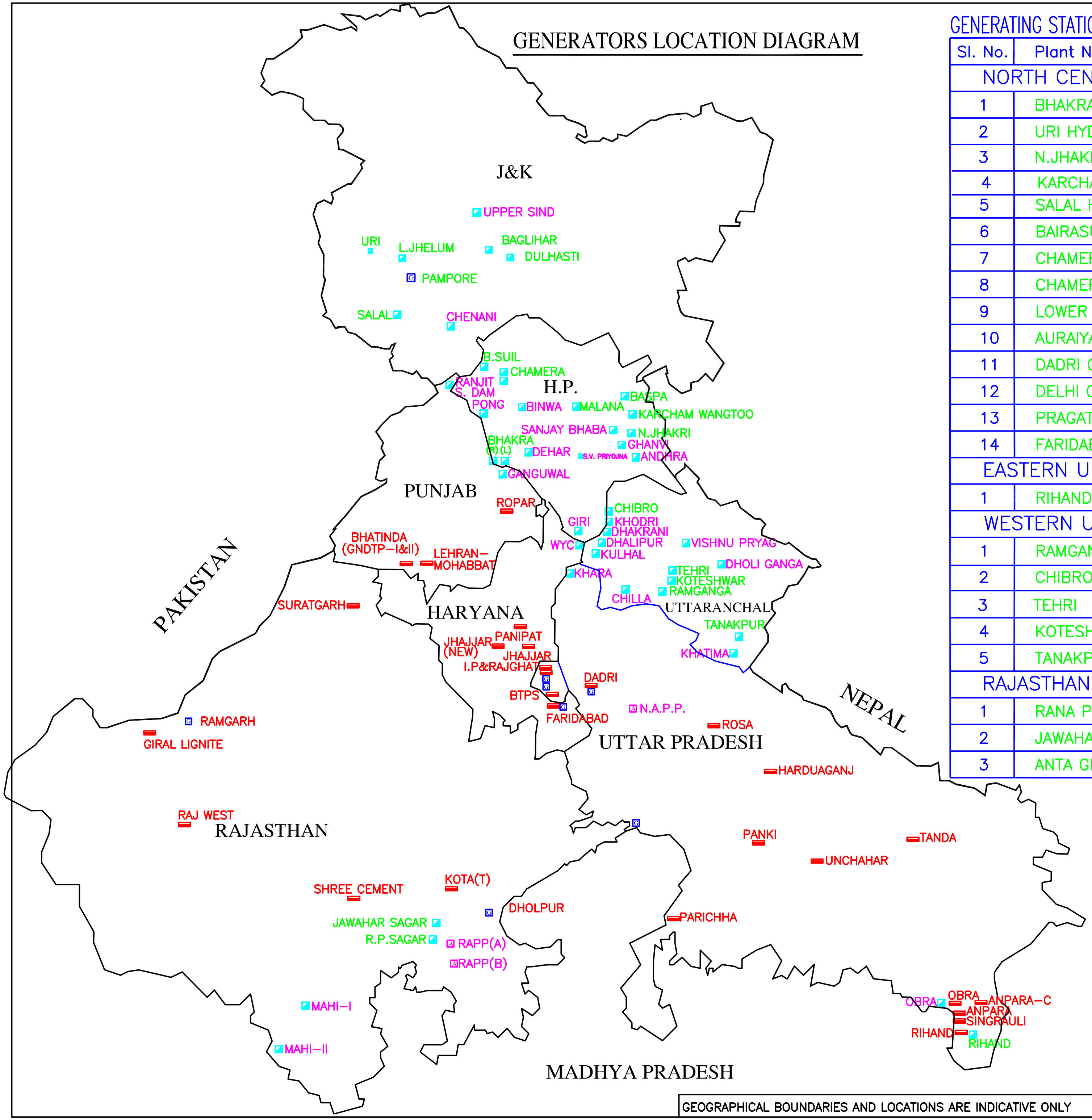
400 केवी उत्तर क्षेत्रीय ग्रिड डायग्राम
400 KV GRID DIAGRAM OF NORTHERN REGION

SCALE : NOT TO SCALE | DRN. Ramjit | DECEMBER. 2011 | 1

GENERATORS LOCATION DIAGRAM



GENERATING STATION WITH BLACK START FACILITY SUB SYSTEM WISE

Sl. No.	Plant Name	Effective Capacity (MW)
	NORTH CENTRAL SUBSYSTEM	
1	BHAKRA (L&R) HYDRO	5x108+5x157=1325
2	URI HYDRO	4x120=480
3	N.JHAKRI	6x250=1500
4	KARCHAM WANGTOO	4x250=1000
5	SALAL HYDRO	6x115=690
6	BAIRASUIL	3x160=180
7	CHAMERA–I	3x180=540
8	CHAMERA–II	3x100=300
9	LOWER JHELUM HYDRO	3x35=105
10	AURAIYA GPS	4x111.19+2x109.30=663.36
11	DADRI GPS	4x130.19+2x154.51=829.78
12	DELHI GPS	6x30+3x34=282
13	PRAGATI GPS	2x104.6+1x121.2=330
14	FARIDABAD GPS	2x137.75+1x156.07=431.57
	EASTERN U.P. SUB SYSTEM	
1	RIHAND HYDRO	6x50.0=300
	WESTERN U.P/UTTRANCHAL SUB SYSTEM	
1	RAMGANGA	3x66.0=198
2	CHIBRO	4x60.0=240
3	TEHRI	4x250=1000
4	KOTESHWAR	4x100=400
5	TANAKPUR	3x131.4=94.20
	RAJASTHAN SUB SYSTEM	
1	RANA PRATAP SAGAR	4x43=172
2	JAWAHAR SAGAR	3x33=99
3	ANTA GPS	3x88.71+1x153.20=419.33

HYDRO POWER STATION
THERMAL POWER STATION
NUCLEAR POWER STATION
GAS TURBINE POWER STATION
HYDRO/GAS POWER STATIONS SELF START

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Generators location diagram

GEOGRAPHICAL BOUNDARIES AND LOCATIONS ARE INDICATIVE ONLY | SCALE : NOT TO SCALE | DRN. BY RAMJIT | REV.-1 | JANUARY, 2012 blank

Annexure-IV

Ready Reckoner on Reactive Power Management.

1. Change in voltage at a bus

$$\frac{\Delta V}{V} = \frac{\Delta Q}{\text{Fault Level of the Bus}}$$

Units: Δ V & V (kV), Δ Q (MVAR), Fault Level (MVA)

2. Fault contribution at HT bus of Unit Transformer:

Sl. No.	Unit Size(MW)	Type	3 Φ MVA Contribution
1	60	Hydro	280
2	120	Thermal	490
3	210	Thermal	735
4	500	Thermal	1800

Thumb Rule: Short circuit level contribution of a generating unit is 3-4 times its MVA rating.

3. Line Charging MVAR:

Sl. No.	Voltage Level (kV)	Conductor Type	Line Charging MVAR/100 km/ckt
1	132	Panther	5
2	220	Zebra	13.5
3	400	Twin Moose	55.5
4	400	Quad Moose	74
5	400	Quad Bersimis (Delhi ring)	74.6
6	765 at 400	Triple Snow Bird	65.6
6	765	Quad Bersimis	291

Source: CEA: Manual on Transmission Planning Criterion, 1994

4. Line Current

Sl. No.	Voltage Level (kV)	Ampere/MVA
1	132	4.4
2	220	2.6
3	400	1.4

5. Voltage rise at receiving end of uncompensated line

Sl. No.	Voltage Level(kV)	Conductor Type (Single circuit)	Voltage Rise (kV) per 100km
1	132	Panther	0.75
2	220	Zebra	1.5
3	400	Twin Moose	3

6. Rated breaking Current Capability of Switch Gear

Sl. No.	Voltage Level (kV)	Kilo ampere
1	765	40
2	400	40
3	220	31.5/40
4	132	25/31

Source: CEA: Manual on Transmission Planning Criterion, 1994

7. MW vs. Current (ampere)

Sl. No.	Voltage Level (kV)	MW
1	400	=2/3 * current (amp)
2	220	=1/3 * current (amp)
3	132	=1/4 * current (amp)

8. Impact of 1000 amp flow on a 100 km Ling 400 kV Line (p.f.=1)

a) I^2 X loss -100 MVAR
b) I^2 R loss -10 MW
c) Potential drop (V_s-Vr) - 3.3 kV

9. Line Charging Guidelines:

- In case, line reactor is available at only one end, it is preferable to charge the line from the end without reactor and synchronize at the end with reactor. If the line is to be opened, open from the end where line reactor is available.
  Thumb rule is "synchronize or open from the end where line reactor is available".
- The line should be charged from the end with higher fault level (3 phase short circuit MVA) in order to limit the over voltage at charging end.
- If two buses have almost same short circuit level (3-ph) and neither is a generation station, charge the line from the bus with lower voltage. At the charging end, all measures should be taken to control high voltage
  a) Bus reactors may be taken in to service
  b) Generators at the charging end may be operated at reduced voltage (less than 1 pu.) and in lagging power factor mode
  c) Suitable measures may be taken to avoid large frequency variations
  d) Loads may be taken into service in small steps.

10. Line Equivalent of a Transformer:

Conductor Type	500 MVA Transformer is equivalent to transmission line (in km)	315 MVA Transformer is equivalent to transmission line (in km)	250 MVA Transformer is equivalent to transmission line (in km)
765 KV Quad Bersimis	559	887	1117
400 kV Quad Bersimis	153	242	305
400 kV Quad Moose Tala	159	253	319
400 kV Triple Snowbird	145	230	290
400 kV Twin Moose	120	191	241
220 kV Zebra	30	48	61

List of Line reactor

Sl No	Lines	Ckt ID	Reactor installed at								Remarks
			End-1	MVAr Rating at End-1	Switchable	Provision to use as Bus Reactor	End-2	MVAr Rating at End-2	Switchable	Provision to use as Bus Reactor	
A. POWERGRID											
1	KISHENPUR-MOGA	1	KISHENPUR	63	---	YES	MOGA	63	---	YES	765kV line charged at 400kV
2	KISHENPUR-MOGA	2	KISHENPUR	63	---	YES	MOGA	63	---	YES	765kV line charged at 400kV
3	TEHRI-MEERUT	1	---	---	---	---	MEERUT	50	YES		765kV line charged at 400kV
4	TEHRI POOLING-MEERUT	2	---	---	---	---	MEERUT	50	YES		765kV line charged at 400kV
5	ABDULLAPUR-JHAKRI	1	ABDULLAPUR	50	---	YES	---	---	---	---	---
6	ABDULLAPUR-JHAKRI	2	ABDULLAPUR	50	---	YES	---	---	---	---	---
7	AGRA(PG)-AURIYA	1	AGRA	50	---	---	---	---	---	---	---
8	AGRA(PG)-AURIYA	2	AGRA	50	---	---	---	---	---	---	---
9	AGRA(PG)-BALLABGARH	1	---	---	---	---	BALLABGARH	50	---	---	---
10	AGRA(PG)-BASSI	1	AGRA	50	---	---	BASSI	50	---	---	---
11	AGRA(PG)-BASSI	2	AGRA	50	---	---	BASSI	50	---	---	---
12	AGRA(PG)-BASSI	3	AGRA	50	---	---	BASSI	50	---	---	---
13	AGRA(PG)-BHIWADI	1	AGRA	50	YES	---	-	-	---	---	---
14	AGRA(PG)-KANPUR	1	AGRA	50		---	KANPUR	50	---	---	---
15	ALLAHABAD-MAINPURI	1	ALLAHABAD	50	YES	---	MAINPURI	80	---	YES	---
16	ALLAHABAD-MAINPURI	2	ALLAHABAD	50	YES	---	MAINPURI	80	---	YES	---
17	ALLAHABAD-RIHAND	2	ALLAHABAD	50	---	YES	-	-	---	---	---
18	ALLAHABAD-RIHAND	1	ALLAHABAD	50	---	YES	-	-	---	---	---

List of Line reactor

Sl No	Lines	Ckt ID	Reactor installed at								Remarks
			End-1	MVAr Rating at End-1	Switchable	Provision to use as Bus Reactor	End-2	MVAr Rating at End-2	Switchable	Provision to use as Bus Reactor	
19	ALLAHABAD-SASARAM	1	-	-	---	---	SASARAM BTB	63	---	---	---
20	BALIA-BIHARSHARIF	1	BALIA	50	---	---	-	-	---	---	---
21	BALIA-BIHARSHARIF	2	BALIA	50	---	---	-	-	---	---	---
22	BALIA-LUCKNOW	1	BALIA	63	---	---	LUCKNOW	63	---	---	---
23	BALIA-LUCKNOW	2	BALIA	63	---	---	LUCKNOW	63	---	---	---
24	KANPUR-BALLABGARH	1	KANPUR	80	---	---	BALLABGARH	80	---	---	---
25	KANPUR-BALLABGARH	2	KANPUR	---	---	---	BALLABGARH	80	---	---	---
26	KANPUR-BALLABGARH	3	KANPUR	80	---	---	BALLABGARH	80	---	---	---
27	BAREILLY (PG)-MANDAULA	1	BAREILLY	50	YES	---	MANDAULA	50	---	---	---
28	BAREILLY (PG)-MANDAULA	2	BAREILLY	50	YES	---	MANDAULA	50	---	---	---
29	BAREILLY(PG)-LUCKNOW(PG)	1	BAREILLY	50	---	---	LUCKNOW	50	---	---	---
30	BAREILLY(PG)-LUCKNOW(PG)	2	BAREILLY	50	---	---	LUCKNOW	50	---	---	---
31	BAREILLY(PG)-LUCKNOW(UP)	1	BAREILLY	50	---	---	LUCKNOW(UP)	50	---	---	Lucknow(UP)-Reactor is of UPPTCL
32	BASSI-BHIWADI	1	BASSI	50	---	YES	---	---	---	---	
33	BASSI-BHIWADI	2	BASSI	50	---	YES	---	---	---	---	
34	KANKRAULI-BHINMAL	1	KANKRAULI	50	---	YES	BHINMAL	50	YES		
35	BHIWADI-HISAR	1	---	---	---	---	HISAR	50		YES	
36	BHIWADI-MOGA	1	---	---	---	---	MOGA	63	---	---	
37	BHIWADI-MOGA	2	---	---	---	---	MOGA	63	---	---	
38	DADRI-MALERKOTLA	1	---	---	---	---	MALERKOTLA	63	---	---	
39	FATEHEBAD-MOGA	1	FATEHABAD	63	---	YES	---	---	---	---	
40	GORAKHPUR(PG)-MUZZFARPUR	1	---	---	---	---	MUZAFFARPUR	63	---	YES	MUZZAFARPUR End is in Eastern Region
41	GORAKHPUR(PG)-MUZZFARPUR	1	---	---	---	---	MUZAFFARPUR	63	---	YES	
42	BHINMAL-ZERDA	1	---	---	---	---	ZERDA	50	---	---	---

List of Line reactor

Sl No	Lines	Ckt ID	Reactor installed at								Remarks
			End-1	MVAr Rating at End-1	Switchable	Provision to use as Bus Reactor	End-2	MVAr Rating at End-2	Switchable	Provision to use as Bus Reactor	
43	GORAKHPUR-LUCKNOW	1	GORAKHPUR	50	YES	---	---	---	---	---	---
44	GORAKHPUR-LUCKNOW	2	GORAKHPUR	50	YES	---	---	---	---	---	---
45	GORAKHPUR-LUCKNOW	3	GORAKHPUR	63	YES	---	LUCKNOW(PG)	63	---	YES	
46	GORAKHPUR-LUCKNOW	4	GORAKHPUR	63	YES	---	LUCKNOW(PG)	63	---	YES	
47	HISSAR-MOGA	1	HISAR	50	---	YES	---	---	---		
48	HISSAR-KAITHAL	1	HISAR	50	---	YES	---	---	---		
49	JHAKRI-NALAGARH	1	---	---	---	---	NALLAGARH	50	---	YES	
50	JHAKRI-NALAGARH	2	---	---	---	---	NALLAGARH	50	---	YES	
51	KAITHAL(PG)-MEERUT(PG)	1	KAITHAL	50	YES	---	---	---	---		
52	KAITHAL(PG)-MEERUT(PG)	2	KAITHAL	50	YES	---	---	---	---		
53	KANKRAULI-RAPP	2	KANKRAULI	50	---	YES	---	---	---		
54	KANKRAULI-RAPP	1	KANKRAULI	50	---	YES	---	---	---		
55	KANKRAULI-ZERDA	1	KANKRAULI	50	---	YES	ZERDA	50	---		
56	KANPUR-SINGRAULI	1	KANPUR	80	---	---	SINGRAULI	80	---		SINGRAULI-Reactor is of NTPC
57	KOTA-MERTA	1	KOTA	50	---	---	MERTA	50	---		
58	KOTA-SHREE CEMENT	1	KOTA	50	---	---	SHREE CEMENT	---	---		
59	MERTA-SHREE CEMENT	1	MERTA	50			SHREE CEMENT	---	---		
60	SARNATH-SASARAM	1	-	---	---	---	SASARAM BTB	63	---		
61	KISHENPUR-WAGOORA	1	WAGOORA	50	---	YES	---	---	---		
62	KISHENPUR-WAGOORA	2	WAGOORA	50	---	YES	---	---	---		
63	DHAULIGANGA-BAREILLY	1	DHAULIGANGA	25	---	---	BAREILLY	---	---		400kV line charged at 220kV
64	KANKROLI-JODHPUR	1	KANKROLI	50	YES	---	JODHPUR	---	---		
B. BBMB											
1	DEHAR-BHIWANI	1	---	---	---	---	BHIWANI	50	---		
2	DEHAR-PANIPAT	1	---	---	---	---	PANIPAT(BB)	71.66	YES		

List of Line reactor

Sl No	Lines	Ckt ID	Reactor installed at								Remarks
			End-1	MVAr Rating at End-1	Switchable	Provision to use as Bus Reactor	End-2	MVAr Rating at End-2	Switchable	Provision to use as Bus Reactor	
C. UPPTCL											
1	ANAPARA-UNNAO	1	---	---	---	---	UNNAO	63	---	---	765kV line charged at 400kV
2	AGRA(UP)-UNNAO	1	AGRA(UP)	50	---	---	UNNAO	50	---	---	
3	ANPARA-MAU	1	ANPARA TPS	63	---	---		---	---	---	
4	AZAMGARH-SARNATH	1	AZAMGARH	50	---	---		---	---	---	
5	BAREILLY(UP)-UNNAO	1	BAREILY (UP)	50	---	---	UNNAO	50	---	---	
6	BAREILLY(UP)-UNNAO	2	BAREILY (UP)	50	---	---	UNNAO	50	---	---	
7	PANKI-MURADNAGAR	1	PANKI	50	---	---	MURADNAGAR	50	---	---	
8	VISHNUPRAYAG-MUZZFARNAGAR	1	VISHNUPRYAG HEP	50	---	---	MUZAFFARNAGAR	50	---	---	
9	VISHNUPRAYAG-MUZZFARNAGAR	2	VISHNUPRYAG HEP	50	---	---	MUZAFFARNAGAR	50	---	---	
10	OBRA-SULTANPUR	1	OBRA-B TPS	50	---	---	SULTANPUR	50	---	---	
11	OBRA-PANKI	1	OBRA-B TPS	50	---	---	PANKI	50	---	---	
12	ANPARA C-ANPARA	1	ANPARA C	110	---	---	ANPARA	---	---	---	Line Reactor belongs to LANCO
D. RRVPNL											
1	HEERAPURA-HINDAUN	1	HEERAPURA	50	YES	---	-	---	---	---	Bus reactor at Heerapura is now used as line reactor
2	CHHABRA-BHILWARA	1	CHHABRA	50	---	---	BHILWARA	50	---	---	
3	CHHABRA-HINDAUN	1	CHHABRA	50	---	---	HINDAUN	50	---	---	
E. NHPC											
1	URI-WAGOORA	1	URI HEP	50	---	---	---	---	---		
2	URI-WAGOORA	2	URI HEP	50	---	---	---	---	---		
3	CHAMERA-I-JALLANDHER	1	CHAMERA-1 HEP	50	---	---	---	---	---		
4	CHAMERA-I-JALLANDHER	2	CHAMERA-1 HEP	50	---	---	---	---	---		
F. NTPC											
1	SINGRAULI-ALLAHABAD	1	SINGRAULI STPS	80	---	---	---	---	---		
2	SINGRAULI-ALLAHABAD	2	SINGRAULI STPS	80	---	---	---	---	---		
3	SINGRAULI-LUCKNOW (UP)	1	SINGRAULI STPS	63	---	---	LUCKNOW(UP)	63	---		Lucknow(UP)-Reactor is of UPPTCL
4	SPARE	1	RIHAND STPS	40	---	---	---	---	---		

List of Bus Reactors

A. POWERGRID

S.No.	Name of Substation	Rating MVAr	Configuration	Remarks
1	ABDULLAPUR	125	3-Φ Unit	
2	ABDULLAPUR	50	3-Φ Unit	
3	ALLAHABAD	80	3-Φ Unit	
4	BALIA	80	3-Φ Unit	
5	BALIA	125	3-Φ Unit	
6	BALLABGARH	80	3-Φ Unit	
7	BAREILLY	80	3-Φ Unit	
8	BASSI	50	3-Φ Unit	
9	BHINMAL	80	3-Φ Unit	
10	CHAMBA	80	3-Φ Unit	
11	FATEHABAD	50	3-Φ Unit	
12	HISSAR	50	3-Φ Unit	
13	KAITHAL	80	3-Φ Unit	
14	KANKRAULI	50	3-Φ Unit	
15	KISHENPUR	63	3-Φ Unit	
16	KOTA	80	3-Φ Unit	
17	LUCKNOW	80	3-Φ Unit	
18	LUCKNOW	125	3-Φ Unit	
19	LUDHIANA	80	3-Φ Unit	
20	MALERKOTLA	50	3-Φ Unit	
21	MANDAULA	50	3-Φ Unit	
22	MOGA	50	3-Φ Unit	
23	NALLAGARH	50	3-Φ Unit	
24	PITHORAGARH	25	3-Φ Unit	Charged at 220 kV
25	PATIALA	125	3-Φ Unit	
26	SONEPAT	125	3-Φ Unit	
27	VINDHYACHAL BTB	93	3-Φ Unit	
28	WAGOORA	50	3-Φ Unit	
B. BBMB				
1	BHIWANI	50	3-Φ Unit	
C. NTPC				
1	DADRI TPS	63	3-Φ Unit	
2	SINGRAULI STPS	50	3-Φ Unit	

List of Bus Reactors

S.No.	Name of Substation	Rating MVAr	Configuration	Remarks
D. PTCUL				
1	RISHIKESH	50	3-Φ Unit	
E. RRVPNL				
1	BARMER	50	3-Φ Unit	
2	BIKANER	50	3-Φ Unit	
3	CHHABRA	50	3-Φ Unit	
4	MERTA	50	3-Φ Unit	
5	RATANGARH	50	3-Φ Unit	
6	AKAL	50	3-Φ Unit	
F. UPPTCL				
1	ANPARA TPS	63	3-Φ Unit	
2	ANPARA C TPS	63	3-Φ Unit	
3	AZAMGARH	50	3-Φ Unit	Presently with Mau Line
4	BAREILY (UP)	63	3-Φ Unit	
5	LUCKNOW (UP)	50	3-Φ Unit	
6	MORADABAD	50	3-Φ Unit	
7	MURADNAGAR	50	1-Φ Unit	Owner is POWERGRID
8	PANKI	50	3-Φ Unit	
9	SARNATH	50	3-Φ Unit	
10	UNNAO	63	3-Φ Unit	
G. HVPNL				
1	KHEDAR	50	3-Φ Unit	
H. Shree Cement				
1	Sh. Cement	80	3-Φ Unit	

Summary of Fault Level at 400kV Buses in Northern Region

Annex-VII

Serial No.	400kV Bus	3-Phase Fault MVA*	
		Off Peak	Peak
1	Abdullapur	15267	15351
2	Agra_PG	19099	19361
3	Agra_UP	15306	15486
4	Allahabad	15593	15650
5	Amritsar	7130	7060
6	Anpara	21326	21328
7	Auraiyya	13603	13693
8	Azamgarh	12448	12508
9	Baglihar	7026	7011
10	Bahadurgarh	14343	14412
11	Balia	13987	14064
12	Ballabgarh	28494	28880
13	Bamnoli	23698	23983
14	Bareilly_UP	14319	14445
15	Bareilly_PG	15324	15459
16	Barmer	6407	6434
17	Baspa	13382	13548
18	Bassi	12900	13056
19	Bawana	29713	30106
20	Bawana_G	29319	29701
21	Bhilwara	3976	3970
22	Bhinmal	4716	4692
23	Bhiwadi	14498	14658
24	Bhiwani	13509	13563
25	Bikaner	4311	4324
26	Chhabra	4433	4441
27	Chamera-1	9112	9048
28	Chamera-2	7967	7913
29	Dadri_HVDC	31214	31562
30	Dadri_NCR	32059	32429
31	Daulatabad	7597	7634
32	Dehar	6727	6732
33	Dulhasti	4411	4378
34	Fatehabad	11806	11889
35	Greater Noida	24085	24315
36	Gorakhpur_UP	10274	10342
37	Gorakhpur_PG	12743	12834
38	Gurgaon	12989	13089
39	Heerapura	11455	11588
40	Hindaun	3113	3132
41	Hissar	19117	19273
42	Jalandhar	13836	13843
43	Jhajjar_New	7838	7880
44	Jhajjar	11777	11869
45	Jodhpur	8849	8890
46	Kaithal	13120	13158
47	Kankroli	8431	8442
48	Kanpur	22121	22276

Serial No.	400kV Bus	3-Phase Fault MVA*	
		Off Peak	Peak
49	Karcham Wangtoo	16030	16242
50	Kashipur	5335	5344
51	Kheddar	11463	11559
52	Kirori	10796	10880
53	Kishenpur	10959	10938
54	Kota	6919	6950
55	Koteswar	9930	9917
56	Lucknow_PG	17376	17517
57	Lucknow_UP	13221	13315
58	Ludhiana	10976	10977
59	Maharanibagh	17526	17677
60	Mainpuri	8314	8360
61	Malerkotla	11271	11288
62	Mandola	31178	31570
63	Mau	13707	13779
64	Meerut	21231	21336
65	Merta	9654	9726
66	Moga	15031	15124
67	Mundka	25484	25799
68	Muradabad	10872	10942
69	Muradnagar	19281	19435
70	Muzzaffarnagar	15007	15069
71	Nallagarh	12162	12182
72	Nathpa Jhakri	17526	17730
73	Obra	12447	12449
74	Panipat	11413	11475
75	Panki	21461	21608
76	Patiala	11451	11464
77	Rajwest	6961	6993
78	RAPS-C	6765	6794
79	Ratangarh	7581	7629
80	Rihand	16888	16895
81	Rihand_HVDC	16674	16680
82	Rishikesh	5907	5913
83	Roorkee	7504	7517
84	Sarnath	13108	13145
85	Shree Cement	5714	5741
86	Singrauli	22269	22278
87	Sonepat_PG	11492	11531
88	Sultanpur	7807	7839
89	Surathgarh	8533	8582
90	Tehri	9456	9442
91	Tehri pooling	10103	10089
92	Unnao	18882	19025
93	Uri-1	5072	5088
94	Vindhayachal	20534	20542
95	Vishnuprayag	3813	3818
96	Wagoora	6554	6555

Annex-VIII

LINE PARAMETERS AND SURGE IMPEDANCE LOADING OF DIFFERENT CONDUCTOR TYPE

Voltage level	Conductor Type	R	X	B	Surge Impedance Z_c=Sqrt (X/B)	SIL= 1*1/Z_c (in pu)	SIL in MW= 100*SIL (in pu)	SIL as per CERC Gazette
765 kV	Quad Bersimis	1.95E-06	4.48E-05	2.40E-02	0.04	23.158	2316	2250
765kV at 400 kV	Quad Bersimis (Kishenpur-Moga)	7.14E-06	1.64E-04	6.56E-03	0.16	6.331	633	-
400 kV	Quad Bersimis Delhi Ring	7.42E-06	1.56E-04	7.46E-03	0.14	6.915	691	691
400 kV	Quad Moose (Tala transmission system)	9.13E-06	1.57E-04	7.40E-03	0.15	6.867	687	-
400 kV	Quad AAAC	9.79E-06	1.68E-04	6.99E-03	0.15	6.458	646	646
400 kV	Quad Zebra	1.05E-05	1.59E-04	6.65E-03	0.15	6.467	647	647
400 kV	Triple Snowbird	1.21E-05	1.72E-04	6.74E-03	0.16	6.254	625	605
400 kV	Triple Zebra	1.40E-05	1.87E-04	5.86E-03	0.18	5.598	560	-
400 kV	Twin Moose	1.86E-05	2.08E-04	5.55E-03	0.19	5.172	517	515
400 kV	Twin AAAC	1.93E-05	2.07E-04	5.67E-03	0.19	5.240	524	425
400 kV	Twin ACAR	1.65E-05	1.94E-04	6.02E-03	0.18	5.574	557	557
220 kV	Single Zebra	1.55E-04	8.25E-04	1.42E-03	0.76	1.312	131	132
132 kV	Single Panther	9.31E-04	2.22E-03	5.10E-04	2.08	0.480	48	50
66 kV	Single Dog	n.a.						10
400 kV	ACKC (500/26)							556
220 kV	Twin Zebra							175

100 MVA Base

Effect of Series Compensation on SIL

At SIL

$I^2X_L = V^2/X_c$

$V^2/I^2 = X_L * X_c$

$Z_c = V/I = Sqrt (X_L * X_c)$

Zc = Sqrt (wL/wC)

Zc = Sqrt (L/C)

$SIL = V^2/Zc$

Series reactance of a series compensated line gets reduced by the % series compensation. So the SIL would increase by a factor of Sqrt [1/(1-%compensation/100)]. For instance in case of Kanpur-Ballabgarh, the SIL without series compensation would be 515 MW. With 35 % compensation, new SIL would be 515/ sqrt(0.65) = 638 MW

Calculation of charging MVAr for a line

400 kV Vindhyachal-Kanpur line having line length of 440 km

Conductor type = Twin Moose

Charging MVAr = (0.00555 x 440) x 100 = 244 MVAr

Calculation of p.u. quantities for 765 kV line charged at 400 kV

765 kV Kishenpur-Moga charged at 400 kV

Conductor type = Quad Bersimis

$X_{new} = X_{old} * (V^2_{old} / V^2_{new})$

X_{new}=4.48E-05* $(765/400)^2$ 0.0001637

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“Another aspect of robustness can be illustrated by the fact that a weaker system that has a well tested plan for emergency procedures and for restoration may be more reliable than a stronger system with no such plan”

Charles Concordia

Dynamic Performance and Security of Interconnected Systems,
IEEE Power Engineering Review, March 1992

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