

**BLACK START FACILITY  
START-UP POWER  
AND  
RESTORATION PROCEDURE  
FOR ODISHA GRID  
(Revision-0)**



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## **1.0 Introduction**

Odisha grid comprises of four numbers of Distribution Utilities operating in the State namely CESU, WESCO Utility, NESCO Utility and SOUTHCO Utility and State Generating Stations, IPPs and CGPs and has an operating area of 166,820 sq km, which is about 36.6 % of the total area of Eastern Region and 4.8% of the total area of the country. OPTCL network has interconnections with States like West Bengal, Jharkhand, Chhatisgarh as well as with neighboring Regions like SR and WR. The state caters to core sector loads, including steel, coal, aluminum and traction. 13,578 ckt-kms lines (132kV and above) and 143 no of sub-stations serve the State, the bulk power being transmitted through the backbone network of OPTCL.

## **2.0 Genesis**

The state restoration procedure, since its earlier publication by SLDC, Bhubaneswar underwent revisions, in consideration of the expansion and changes taking place over the years in the state grid.

In compliance with clause 5.8 (a) and (b) of IEGC Regulations, 2010 and 5.9 (1) and (2) of the OGC Regulations, 2015, the restoration procedure has to be annually updated and finalized by SLDC in consultation with all the users of the state grid. In order to accomplish this objective, SLDC has interacted with the State entities. Also SLDC participated in the workshops conducted by ERLDC, wherein the restoration procedure was deliberated in detail. The present revision has been done based on information obtained from the entities and conclusions drawn in the said workshops.

## **3.0 Scope & Objective**

This document describes the procedures to be followed by SLDC in coordination with ERLDC, for restoration of the State grid following a complete or partial collapse.

The objective of this procedure is to achieve restoration of the total state EHV power system in the shortest possible time viz.

- Secure generation
- Secure transmission
- Restore interconnection with neighbours
- Avoid utility / consumer plant damage
- Restore demand

## **4.0 GENERAL CRITERIA - METHODOLOGY TO BE FOLLOWED IN CASE OF GRID COLLAPSE**

1. SLDC shall inform the power stations who have black start facilities to take immediate action.
2. While choosing the path for start-up power, 220 kV and above lines are to be avoided as far as possible to avoid over voltage.
3. Minimum number of sections in 132 kV are to be chosen to avoid coordination and switching problem.
4. If required, load is to be released in a coordinated manner as far as possible at intermediate sub-stations to arrest over-voltage, if any.

5. To avoid unbalancing, phase balancing should be kept in view if traction load is released.
6. Generator loading which is supplying start-up power should be checked and total loading should not cross 80% of its capacity. Efforts should be made to keep the generator operating to lagging side, if not possible at least to near unity power factor.
7. Thermal stations should be provided survival power as early as possible to avoid damage to the equipment in case of D.C. failure. (e.g. Barring gear, lub oil, seal oil, compressor for circuit breakers etc.). Operator should be able to distinguish between start-up and survival power.
8. Auxiliary power should be released in steps so that all the running units could be started gradually.
10. Check the sub-stations which have synchronising facilities in proper working order/capabilities (it is apprehended that due to continuous integrated operation, Operating personnel have lost the experience of synchronising the lines in most of the sub-stations). Rough synchronisation should be avoided as small system may not be able to take the jerk.
11. In order to increase spinning reserve in healthy system, if required shedding should be done in islands which have survived.
12. The start-up procedure should be known to everyone and working level personnel should do it without referring or waiting for management's consent during the crisis.
13. Priorities of load which is to be connected in steps should be documented and while releasing loads for example Traction loads, underground coal mines/deep gassy mines/AIR/TV/Telephone exchange, hospital, pumping station etc. should be given priority depending on available generation.
14. Tap position of station transformers, bus voltage, frequency etc. in the power stations should be carefully monitored to see that over fluxing do not occur when efforts are on to bring the unit back.
15. To control over-voltage, following may be considered as per requirement of situation.
  - \_ start synchronous condenser wherever available.
  - \_ keep GTs running
  - \_ Back charging from 132 kV side of transformer without loading the same.
    - i) 132/33 kV transformer
    - ii) 132/220 kV auto transformer
    - iii) 220/400 kV auto transformer
    - iv) 400 kV bus reactor; if required by tap changing
16. The following 132 kV lines which are normally kept off may be required to be used during start-up procedure. The lines, therefore, should be tested once in a month for its healthiness. The communication between the concerned stations should be kept healthy.
  - Joda-Kendposi 132 kV S/C (GRIDCO/JSEB)
17. A list of telephone nos. of all the sub-stations should be available at plant and at SLDC as communication is the essential requirement during the restoration process.

18. Before asking power station to draw start-up power, the capacity of island to sustain the starting current of biggest Induction Motor (generally BFP) should be checked.
19. Priority should be attached to provide support power to captive units in case they request and vice-versa.
20. It is felt that there is a need for a strategy of restoration to be available rather than detail. Details with 1st, 2nd & 3rd alternative may be drawn up by SLDC under intimation to ERLDC.

### **5.0 General principle followed while formulating the restoration plans for individual power stations:**

**Case (A):** Total collapse of the State system – Priority wise sources identified in neighbouring systems, from which power can be extended to the power station(s) of the State..

**Case (B):** Total black out of the individual power station only – The first priority of availing assistance should be from the other part of the State. In case this is not possible, assistance should be availed from neighbouring system. However, the above priority may change, depending upon station specific factors / advantages.

### **SOME DON'TS**

- a) Do not load lines beyond 80% capacity.
- b) Do not hastily connect loads and do not allow frequency to come below 50 Hz in any case. The case of any surviving island or even unit with house-load should be informed to SLDC.
- c) Once power is extended to a power station, it should not be disconnected except emergency as all actions taken by the power station have to be redone.
- d) Till the restoration process is over, SLDC should not be disturbed in any way for working as Management Information System.
- e) No commercial problem should be brought up for extending power during restoration process.
- f) Communication links should not be made unnecessarily busy during Start-up process.

### **6.0 Power Stations with Black Start facility**

<b>Sl. No</b>	<b>Name of Power Station</b>	<b>Unit Capacity (MW)</b>	<b>Type</b>	<b>Source</b>	<b>Capacity</b>
1	Rengali	5x50	Hydro	Diesel	1 X 750 kVA
2	Upper Indravati	4x150	Hydro	Diesel	2 X 650 kVA
3	Balimela	6x60+2x75	Hydro	Diesel	1 X 750 kVA
4	Upper Kolab	4x80	Hydro	Diesel	1 X 750 kVA
5	Burla	2x49.5+2x32+3x37.5	Hydro	Diesel	1 X 750 kVA
6	Chipilima	3x24	Hydro	Diesel	1 X 500 kVA

## 6.1 List of Power stations and S/S having synchronizing facility.

Sl No	Name of Power Station / S/S	Voltage level
1	Rengali	220 kV
2	Upper Indravati	220 kV
3	Balimela	220 kV
4	Upper Kolab	220 kV
5	Burla	132 kV
6	Chipilima	132 kV
7	IBTPS	220 kV
8	TTPS	220 kV
9	Vedanta Ltd IPP	400 kV
10	GMR, Kamalanga	400 kV
11	Bhanjanagar	220 kV
12	Theruvai	220 kV
13	Jayanagar	220 kV
14	Joda	220 kV
15	Meramundali	400 / 220 kV
16	Mendhasal	400 / 220 kV
17	Balasore	220 kV
18	Barkote	220 kV
19	Bidanasi	220 kV
20	Budhipadar	220 kV
21	Chandaka	220 kV
22	Duburi	220 kV
23	Duburi (New)	400 / 220 kV
24	Narendrapur	220 kV
25	Tarkera	220 kV

## 6.2 Restoration plan for State Hydro Stations

POWER STN.	PRIORITY:I	PRIORITY:II	PRIORITY:III	PRIORITY:IV
RENGALI	HOUSE SET	TSTPP (NTPC)	TTPS	RENGALI(PG)
BALIMELA	HOUSE SET	JAYNAGAR (MACHHKUND)	JEYPORE (POWERGRID)	UPPER KOLAB
UPPER KOLAB	HOUSE SET	JAYNAGAR		
HIRAKUD-I (BURLA)	HOUSE SET	KATAPALI	SAMBALPUR	
HIRAKUD-II (CHIPLIMA)	HOUSE SET	BURLA	KATAPALI	
INDRAVATI	HOUSE SET	JEYPORE (POWERGRID)	THERUVALI	
IBTPS (OPGC)	BUDHIPADAR	KORBA (MPEB)		
TTPS (NTPC)	BURLA/ANGUL	MERAMUNDALI	RENGALI	TSTPP

### 6.3 Restoration Path

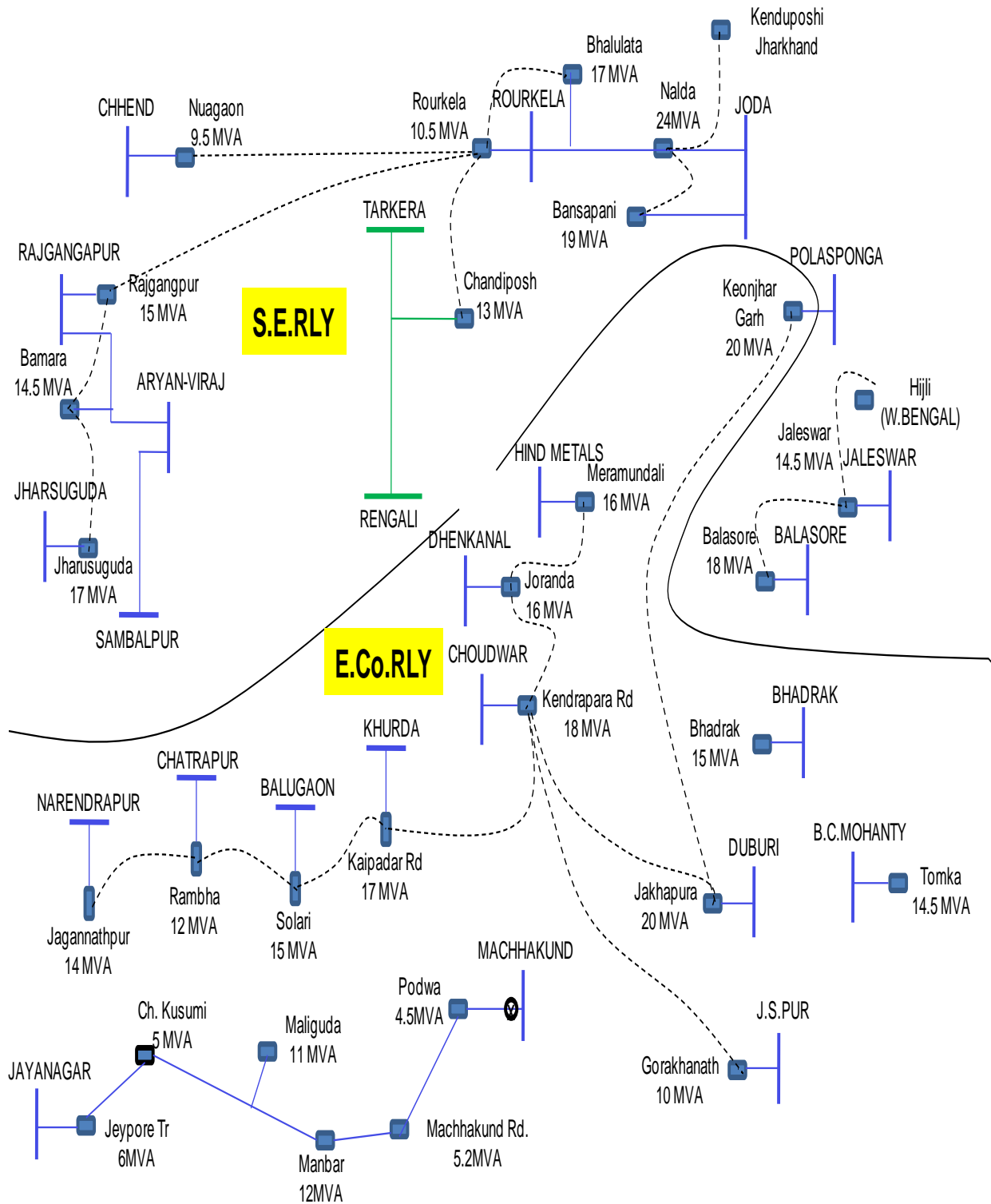
<b>1. RENGALI HPS</b>	
A. Total collapse of GRIDCO system but power available from neighboring system	<ul style="list-style-type: none"> <li>i) Black start of own house set</li> <li>ii) 220 KV Rengali HPS –TTPS-Meramandali- NALCO (if the CPPsurvived after islanding from GRIDCO).</li> <li>iii) 220 KV Rengali HPS- TSTPP.</li> <li>iv) 220 KV Rengali HPS-Rengali S/yard-Rengali (PG).</li> <li>v) 220 KV Rengali HPS-Rengali S/yard-Tarkera-Rourkela (PG).</li> </ul>
B. Outage of all running units	<ul style="list-style-type: none"> <li>i) 220 KV Rengali HPS – TTPS-Meramandali- NALCO</li> <li>ii) 220 KV Rengali HPS-Rengali S/s (GRIDCO)-Tarkera.</li> <li>iii) 220 KV Rengali HPS-TSTPP.</li> <li>iv) Black start of own house set</li> </ul>
<b>2. BALIMELA HPS</b>	
A. Total collapse of GRIDCO system but power available from neighbouring system.	<ul style="list-style-type: none"> <li>i) Black start of own house set</li> <li>ii) 220 kV Balimela-Jaynagar-Jeypore (PG).</li> <li>iii) 220 kV Balimela-Jaynagar (GRIDCO)-132 kV Jaynagar-Machkund-Vizag(APTRANSCO).</li> </ul>
B. Outage of all running units only.	<ul style="list-style-type: none"> <li>i) 220 kV Balimela-Jaynagar-Upper Kolab.</li> <li>ii) 220 kV Balimela-Jaynagar-Jeypore (POWERGRID)</li> <li>iii) 220 kV Balimela-Jaynagar-Theruvalli-Bhanjanagar-Meramundali</li> <li>iv) 220 kV Balimela-Jaynagar-Theruvalli-Indravati(GRIDCO)</li> <li>v) Black start of own house set</li> </ul>
<b>3. UPPER KOLAB HPS</b>	
A. Total collapse of GRIDCO system but power available from neighbouring system	<ul style="list-style-type: none"> <li>i) Black start of own house set</li> <li>ii) 220 kV Upper Kolab-Jaynagar and 132 KV Jaynagar- Machkund-Vizag.(AP)</li> <li>iii) 220 kV Upper Kolab-Jaynagar-Jeypore (PG).</li> <li>iv) 220 kV Upper Kolab- Jaynagar-Balimela-Upper Sileru(AP).</li> </ul>
B. Outage of all running units only.	<ul style="list-style-type: none"> <li>i) 220 kV Upper Kolab-Jaynagar-Balimela.</li> <li>ii) 220 kV Upper Kolab-Theruvalli-Indravati</li> <li>iii) 220 kV Upper Kolab-Jaynagar and 132 KV Jaynagar-Machkund.</li> <li>iv) 220 kV Upper Kolab-Jaynagar-Jeypore (PG).</li> <li>iv) Black start of own house set</li> </ul>
<b>4. BURLA HPS</b>	
A. Total collapse of GRIDCO system but power available from neighbouring system	<ul style="list-style-type: none"> <li>i) Black start of own house set</li> <li>ii) 132 kV Burla- Lapanga-Budhipadar-220 kV Budhipadar-Korba(WR)</li> <li>iii) 132 kV Burla- Sambalpur-Rairakhhol-Boinda -Angul-Talcher TPS - 220kV TSTPP</li> <li>iv) 132 kV Burla-Katapali-220kV Katapali-Bolangir(PG)</li> </ul>

	<ul style="list-style-type: none"> <li>iv) 132 kV Burla-Katapali-220kV Katapali-Lapanga-Budhipadar-Korba(WR)</li> <li>v) 132 kV Burla- Hindalco / 220kV Hindalco- Katapali (if the CPP survived after islanding)</li> <li>vi) 132 kV Burla-Lapanga-SMC (if the CPP survived after islanding)</li> <li>vii) 132 kV Burla-Sambalpur-Shyam DRI- Aryan Ispat (if the CPP survived after islanding)</li> <li>viii) 132 kV Burla-Budhipadar-220 kV Budhipadar-VAL (if the CPP survived after islanding)</li> </ul>
B. Outage of all running units only.	<ul style="list-style-type: none"> <li>i) 132 KV Burla- Lapanga</li> <li>ii) 132 KV Burla-Sambalpur-Rairakhol-Boinda-Angul-Talcher TPS - 220 KVTSTPP</li> <li>iii) 132 kV Burla- Hindalco</li> <li>iv) 132 kV Burla- Katapali-220kV Katapali-Bolangir(PG).</li> <li>v) 132 kV Burla- Chiplima</li> <li>vi) Black start of own house set</li> </ul>
<b>5. CHIPLIMA HPS</b>	
A. Total collapse of GRIDCO system but power available from neighbouring system	<ul style="list-style-type: none"> <li>i) Black start of own house set</li> <li>ii)132 KV Chiplima-Burla- Lapanga-Budhipadar-220 kV Budhipadar-Korba( WR)</li> <li>iii) 132 KV Chiplima-Burla-Sambalpur-Rairkhol-Angul-Talcher TPS - 220 kVTSTPP.</li> <li>iv)132 kV Chiplima-Katapali-220kV Katapali-Lapanga-Budhipadar-Korba(WR)</li> <li>iv)132 kV Chiplima-Katapali-220kV Katapali-Bolangir(PG)</li> <li>v)132 kV Chiplima-Burla-Lapanga-SMC(if the CPP survived after islanding)</li> <li>vi)132 kV Chiplima-Burla-Sambalpur-Shyam DRI- Aryan Ispat (if the CPP survived after islanding)</li> </ul>
B. Outage of all running units only.	<ul style="list-style-type: none"> <li>i) 132 KV Chiplima-Burla.</li> <li>ii) 132 kV Chiplima-Katapali</li> </ul>
<b>6. INDRAVATI HPS</b>	
A. Total collapse of GRIDCO system but power available from neighbouring system	<ul style="list-style-type: none"> <li>i) Black start of own house set</li> <li>ii) 400 kV Indravati HPS-Indravati (PG)</li> <li>iii) 220 kV Indravati - Theruvali</li> </ul>
B. Outage of all running units only.	<ul style="list-style-type: none"> <li>i) 220 kV Indravati - Theruvali</li> <li>ii) 400 kV Indravati HPS-Indravati (PG)-Jeypore (PG).</li> <li>iii) Black start of own house set</li> </ul>
<b>7. IB TPS</b>	
A. Total collapse of GRIDCO system but power available from	<ul style="list-style-type: none"> <li>i) 220 kV IBTPS-Budhipadar-Lapanga-Katapali-Bolangir (PG).</li> <li>ii) 220 kV IBTPS-Budhipadar-Korba (WR).</li> <li>iii) 220 kV IBTPS-Budhipadar-Vedanta/ BPSL / AAL (if the CPP</li> </ul>

neighbouring system	survived afterislanding)
B. Outage of all running units only.	i) 220 kV IBTPS-Budhipadar-Lapanga-Katapali-Bolangir (PG). ii) 220 kV IBTPS-Budhipadar& 132 KV B'padar- Lapanga.
<b>8. NTPC (TTPS)</b>	
Total collapse of TTPS and isolated from Eastern Region grid but power available in neighbouring system	i) 132 kV Talcher TPS-Angul-Boinda-Rairakhol-Sambalpur-Burla HPS ii) 220 kV Talcher TPS-Meramandali-NALCO (if the CPP survived after islanding) iii) 220 kV Talcher TPS-TSTPP (NTPC) iv) 220 kV Talcher TPS-TSTPP (NTPC)-Rengali HPS
Extension of supply to GRIDCO power stations in case of total collapse of Eastern Grid.	i) 220 kV IBTPS-Budhipadar-Korba (WR). ii) 220 kV Balimela-Upper Sileru (AP). iii) 400 kV Gazuwaka-Jeypore-Indravati (POWERGRID)-Indravati.



# TRACTION SUB-STATIONS WITH CONTRACT DEMANDS



## TRACTION LOAD DETAILS

Sl. No.	Traction Sub-station	Connected Grid / EHT Line	CD (MVA)
<b>EAST COAST RAILWAY</b>			
1	Jagannathpur	Narendrapur	14.00
2	Rambha	Chhatrapur	12.00
3	Solari	Balugaon	15.00
4	Kaipadar Road	Khurda	17.00
5	Kendrapara Road	Choudwar	18.00
6	Gorakhnath	Jagatsinghpur	10.00
7	Joranda	Dhenkanal	16.00
8	Meramundali	Meramundali	16.00
9	Jakhapura	Duburi	20.00
10	Bhadrak	Bhadrak	15.00
11	Keonjhargarh	Palasponga	20.00
12	Machhkund Rd	132kV Machhkund - Jayanagar Fdr	5.20
13	Padwa		4.50
14	Manbar		12.00
15	Maliguda		11.00
16	Jeypore Trac.		5.00
17	Ch. Kusumi		6.00
18	Tomka	B.C Mohanty Sw. Stn.	14.50
<b>SOUTH EASTERN RAILWAY</b>			
1	Jharsuguda	Jharsuguda	17.00
2	Bamra	132kV Sambalpur - RKL Ckt-III	14.50
3	Rajgangpur	Rajgangpur	15.00
4	Chandiposh	220kV Rengali - Tarkera Fdr	13.00
5	Rourkela	Rourkela	10.50
6	Bhalulata	132kV Joda - RKL Fdr	17.00
7	Nuagaon	Chhend	9.50
8	Nalda	132kV Joda - RKL Fdr	24.00
9	Bansapani	Joda	19.00
10	Balasore	Balasore	18.00
11	Jaleswar	Jaleswar	14.50

## **7.0 Procedure for periodic exercise of blackstart**

### **Background**

In compliance with the provisions of IEGC / OGC, periodic testing of black-start facilities is required to be undertaken in the State as part of preparedness to combat emergency conditions in the State grid. Accordingly, mock black start exercises are required to be carried out in a phased manner.

As per the programme decided in the ERPC meeting, ERLDC drafted a plan indicating details of load segregation in the State and switching actions to be carried out in the process of implementation of the mock exercise.

The same is being circulated to the power station and the grid S/S involved for formation of the island.

### **7.1 Procedure for periodic exercise of black starting Upper Kolab HEP**

#### **Network configuration required:**

#### **Bus segregation required at UKHEP**

At UKHEP, Bariniput both the Bus (Bus - A & B) cannot be used simultaneously due to non provision of independent PT supply to both Bus. One of the unit, identified to be black-started and the 220kV Upper Kolab-Theruvalli circuit are to be connected to any one of the 220kV Buses while rest of the units and lines shall be kept 'OFF'.

#### **Bus segregation required at Theruvalli Sub-station (220 kV )**

The 220 kV switchyard of the sub-station is having one-and-half breaker configuration. The 220 kV Upper Kolab-Theruvalli line (charged from the isolated UKHEP unit) and one 100 MVA, 220/132 kV Auto Transformer are to be connected to one of the 220 kV buses, while all other lines and 2<sup>nd</sup> Auto Transformer are to be connected to the other 220 kV bus.

#### **Bus segregation required at Theruvalli Sub-station (132 kV)**

The 132 kV switchyard is having main and transfer configuration. One feeder which can provide at least 50 MW stable, balanced load and can be interrupted for short duration, is to be connected with the transfer bus along with the 220/132 kV Auto Transformer to be charged from UKHEP. All other feeders, Auto Transformer to be kept connected to the other bus.

#### **Switching operation at Theruvalli**

The 220 kV Upper Kolab-Theruvalli circuit and 220/132 kV Auto Transformer-1 are to be connected only to 220 kV Bus-1 by switching off their respective the CBs with Bus 2. The main CBs of 220 kV Bhanjanagar 1 & 2 and Narendrapur 1 & 2 feeders, Indravati-1, 2, 3 & 4 feeders, connected to Bus 1 are to be switched off. The tie-breakers of these feeders shall be in closed position to enable their connectivity with Bus-2. Auto Transformer-2 shall be kept on Bus-2 only by opening the tie-breaker.

Kesinga, Junagarh, Bhawanipatna & POWMEX load (amounting 55 MW approximately) is to be supplied from the isolated UKHEP unit along with the 220/132 kV Auto Transformer-1, through 220kV Bus-I and 132kV Transfer Bus.

### **Switching operation at UKHEP**

The selected unit and 220 kV Theruvali circuit to be switched off and connected to the selected 220kV Bus. Other feeders and units are to be kept 'OFF'.

### **The procedure**

As the exercise is planned to be carried out during off-peak hours, if required, additional units at Balimela and UIHEP will have to be kept synchronized with the South Odisha system to maintain the requisite fault level. Availability of data and voice communication of Theruvali, Jaynagar, Upper Kolab, Balimela and Indravati is also to be checked.

The selected unit of UKHEP is to be self-started with the help of DG and 220 kV UKHEP-Theruvali to be charged. At Theruvali 220 kV CB for Auto Transformer-1 is to be closed. 132 kV side of Auto Transformer-1 is to be connected with the Transfer Bus. This will also charge the 132 kV load feeder. Load is then to be released gradually taking care to maintain the island frequency and voltages at UKHEP and Theruvali within acceptable limits. Load is to be released gradually as per the direction of SLDC. The islanded operation of the unit may be continued for around 15 minutes. After successful completion, the island is to be synchronized with the system at Theruvali / Upper Kolab PH as per the instruction of SLDC and normal configuration is to be restored.

## SEQUENCE OF OPERATION:

1. 220 kV Upper Kolab-Theruvalli Ckt. shall be made OFF from both the ends.
2. At Upper Kolab PH switchyard, all outgoing 220 kV feeders i.e. Jaynagar-I & II, all running units shall be made 'OFF'.
3. At Upper Kolab PH switchyard, 220 kV Theruvalli Ckt. and the identified unit for black start shall be kept on the selected 220 kV Bus.
4. At Theruvalli grid sub-station, 220 kV Upper Kolab (Jaynagar ckt.-III), Auto-I shall be transferred to 220kV Bus-I.
5. At Theruvalli grid sub-station, 220 kV Indravati Ckt.-I, II, III & IV, Jayanagar-I & II, Auto Transformer-II, Bhanjanagar-I & II, Narendrapur-I & II shall be transferred to 220kV Bus-II.
6. At Theruvalli grid sub-station, 132 kV side of Auto-I, 132 kV Kesinga feeder shall be kept on 132 kV Transfer Bus.
7. At Theruvalli grid sub-station, 132 kV Bus Coupler is to be made open.
8. At Upper Kolab PH, the identified unit shall be started by availing auxiliary power supply from DG set and charged the selected Bus. The DG set starting time and the output parameters shall be recorded.
9. M/s. VAL, Langigarh shall be intimated by Theruvalli to remain in islanding mode of operation to avoid its unit tripping.
10. At Theruvalli grid sub-station, 220 kV bus-coupler breaker shall be OPENED so that only 220 kV Upper Kolab (Jaynagar ckt.-III) along with Auto-I shall remain on Bus-I. 132 kV Kesinga feeder is to be charged from the supply available from Auto-I, needs to be hand tripped and connected to 132kV Transfer Bus.
11. At Upper Kolab PH switchyard, 220 kV Theruvalli (Jaynagar ckt.-III) shall be charged from the black started unit through selected 220kV Bus.
12. At Theruvalli grid sub-station, the 220 kV Bus-I shall be charged by availing power supply through Upper Kolab (Jaynagar ckt.-III) and subsequently Auto-I shall be charged.
13. At Theruvalli grid sub-station, 132 kV Kesinga feeder shall be charged and gradually loaded.

14. At each step, Theruvali grid sub-station and Upper Kolab PH shall record all the parameter readings such as Power Flow (both MW & MVAR), Frequency, Voltage etc.

15. The island so formed shall be synchronized with the system at Theruvali grid sub-station / Upper Kolab PH as per the direction of SLDC.

16. All operations shall be carried out in co-ordination with SLDC.

The electrical parameters at different time period of operation and the activity time should be recorded at Upper Kolab HPS in the format given below.

Sl. No.	Parameters	Time	Time	Time	Time	Time
1.	Frequency (Hz)					
2.	Load (MW)					
3.	Generator Voltage (kV)					
4.	220kV isolated Bus Voltage (kV)					
5.	Reactive Power (MVAR)					
6.	Generator Current (kA)					
7.	Power Factor (lead / lag)					

Activity	Time (Minutes)
Time taken to start DG set after black out of Island	
Time taken to charge dead bus at Black start station	
Time taken to charge dead bus at Remote end by line charging	
Time taken to connect first load post a black out in the island	
Duration of stable island operation after successful black start and building up the of the island till synchronization with grid	
Time taken to synchronize the island with Grid	

## **7.2 Procedure for periodic exercise of black starting Balimela HEP**

### **Switching operations required:**

#### **At Balimela Power House (OHPC) 220kV switchyard**

- At Balimela HPS, the unit to be black-started and the 220kV Balimela (OHPC)-Balimela (OPTCL) circuit to be charged by this unit to remain connected at one 220kV bus while rest of the units and lines to be shifted to the other 220kV bus, by opening the 220kV main bus coupler CB. 220KV Balimela (OHPC) –Jayanagar Ckt.-II shall be kept open.

#### **At Balimela sub-station (OPTCL) 220kV switchyard**

- At Balimela (OPTCL) 220kV breakers of 220KV Balimela (OHPC)-Balimela (OPTCL) Ckt. and 220KV Balimela (OPTCL) –Jayanagar Ckt.-II shall be kept open.

#### **At Jayanagar sub-station (OPTCL) 220kV switchyard**

- 220KV Balimela (OHPC) –Jayanagar Ckt.-II shall be kept open.

### **Sequence**

1. At Balimela (OPTCL) sub-station, 220kV breakers of 220KV Balimela (OHPC)-Balimela (OPTCL) Ckt. and 220KV Balimela (OPTCL) –Jayanagar Ckt.-II shall be opened as per instruction of SLDC.
2. At Balimela HPS, the unit to be black-started and the 220kV Balimela (OHPC)-Balimela (OPTCL) ckt to be charged from Balimela HPS shall be kept on one bus and all other available units and lines shall be transferred to other 220kV bus. 220KV Balimela (OHPC) –Jayanagar Ckt.-II shall be kept open.
3. On receipt of clearance from SLDC, Balimela HPS should start up the identified unit using the DG set as the source of auxiliary supply and charge the dead 220kV station bus.
4. The selected unit should have its AVR and governor action activated. Terminal voltage should be maintained at 75-80 percentage of the rated value.
5. On receipt of clearance from SLDC as well as Balimela (OPTCL) sub-station, the 220kV Balimela (OHPC)-Balimela (OPTCL) circuit is to be idle charged from Balimela HPS.
6. Assuming the minimum stable generation level of Balimela unit to be 20 to 30 MW, load of the same order is to be released by connecting 33kV feeders at Balimela (OPTCL) sub-station.
7. The island created should operate stably for around ten minutes and to be synchronized at Jayanagar Grid substation as per the instruction of SLDC through 220kV Balimela (OPTCL)- Jayanagar Ckt.- II.

8. During the exercise, SLDC, OPTCL may keep record of the time of issuance of every instruction and time of actual execution of the switching operation.
9. Additional data such as frequency and voltage of the isolated Balimela (OPTCL) 220kV bus, terminal voltage, MW and MVAR of the unit should also be recorded by Balimela(OHPC)/ Balimela (OPTCL)/SLDC.
10. The electrical parameters at different time period of operation and the activity time should be recorded at Balimela PH in the format given below

Sl. No.	Parameters	Time	Time	Time	Time	Time
1.	Frequency (Hz)					
2.	Load (MW)					
3.	Generator Voltage (kV)					
4.	220kV isolated Bus Voltage (kV)					
5.	Reactive Power (MVA <sub>r</sub> )					
6.	Generator Current (kA)					
7.	Power Factor (lead / lag)					

Activity	Time (Minutes)
Time taken to start DG set after black out of Island	
Time taken to charge dead bus at Black start station	
Time taken to charge dead bus at Remote end by line charging	
Time taken to connect first load post a black out in the island	
Duration of stable island operation after successful black start and building up the of the island till synchronization with grid	
Time taken to synchronize the island with Grid	



### 7.3 Procedure for periodic exercise of black starting Indravati HEP

#### 1. **Bus segregation required at UIHEP**

The 220 kV switchyard of this station is of 2-main + 1 transfer configuration. On one 220 kV main bus, one hydro unit and one circuit of 220 kV Indravati-Theruvalli line are to be connected while all other units, lines and transformers to be connected to the other main bus.

#### 2. **Bus segregation required at Theruvalli Sub-station (220 kV )**

The 220 kV switchyard of the sub-station is having one-and-half breaker configuration. One circuit of 220 kV Indravati-Theruvalli line (charged from the isolated UIHEP unit) and one 100 MVA, 220/132 kV Auto Transformer are to be connected to one of the 220 kV buses, while all other lines and 2<sup>nd</sup> Auto Transformer are to be connected to the other 220 kV bus.

#### 3. **Bus segregation required at Theruvalli Sub-station (132 kV)**

The 132 kV switchyard is having main and transfer configuration. One feeder which can provide at least 50 MW stable, balanced load and can be interrupted for short duration, is to be connected with the transfer bus along with the 220/132 kV Auto Transformer to be charged from UIHEP. All other feeders, Auto Transformer to be kept connected to the other bus.

#### 4. **Switching operation at Theruvalli**

The 220 kV Indravati-Theruvalli circuit-3 and 220/132 kV Auto Transformer-1 are to be connected only to 220 kV bus-1 by switching off their respective the CBs with bus 2. The main CBs of 220 kV Bhanjanagar 1 & 2 and Narendrapur 1 & 2 feeders, Indravati-1, 2 & 4 feeders, connected to Bus 1 are to be switched off. The tie-breakers of these feeders shall be in closed position to enable their connectivity with bus-2. Auto Transformer-2 shall be kept on bus-2 only by opening the tie-breaker.

Kesinga, Junagarh, Bhawanipatna & POWMEX load (amounting 55 MW approximately) is to be supplied from the isolated UIHEP unit along with the 220/132 kV Auto Transformer-1, by isolating 132 kV main bus section.

#### 5. **Switching operation at UIHEP 220 kV**

The selected unit and 220 kV Theruvalli circuit-3 to be switched off and connected to Main Bus-2. Other feeders, ICTs and units are to be connected to Main Bus-1. By opening the bus coupler CB, the selected unit and 220 kV UIHEP-Theruvalli Ckt. 3 will get isolated.

6. **The procedure**

As the exercise is planned to be carried out during off-peak hours, if required, additional units at Balimela and / or U.Kolab and UIHEP will have to be kept synchronized with the South Odisha system to maintain the requisite fault level. Further, before carrying out the trial operation, it is to be ensured that both the 400/220 kV ICTs at Jeypore and Indravati and 220 kV Jeypore-Jayanagar D/C line are in service. Availability of data and voice communication of Jeypore and Indravati with ERLDC and between UIHEP and Theruvali is also to be checked.

7. **The entire operation is to be co-ordinated by SLDC.**

The selected unit of UIHEP is to be self-started with the help of DG and 220 kV UIHEP-Theruvali Ckt.-3 to be charged. At Theruvali 220 kV CB for Auto Transformer-1 is to be closed. 132 kV side of Auto Transformer-1 is to be connected with the (main) Bus Section. This will also charged the 132 kV load feeder. Load is then to be released gradually taking care to maintain the island frequency and voltages at UIHEP and Theruvali within acceptable limits. Around 50 MW load is to be released as the unit can run stably with a minimum of this quantum of load. The islanded operation of the unit may be continued for around 15 minutes. After successful completion, the island is to be synchronized with the system at Theruvali / Indravati PH as per the instruction of SLDC and normal configuration is to be restored.

**SEQUENCE OF OPERATION:**

1. 220 kV Indravati-Theruvali Ckt.-3 shall be made OFF from both the ends.
2. At Indravati PH switchyard, all outgoing 220 kV feeders i.e. Theruvali-I, II & IV, ICT I & II, all running units shall be kept on Bus-I.
3. At Indravati PH switchyard, 220 kV Theruvali Ckt.-III and the identified unit for black start shall be kept on 220 kV bus-II. Bus coupler breaker shall be kept OFF.
4. At Theruvali grid sub-station, 220 kV Indravati Ckt.-III, Auto-I shall be transferred to Bus-I.
5. At Theruvali grid sub-station, 220 kV Indravati Ckt.-I, II & IV, Jayanagar-I & II, Kolab-III, Auto Transformer-II, Bhanjanagar-I & II, Narendrapur-I & II shall be transferred to Bus-II.
6. At Theruvali grid sub-station, 132 kV side of Auto-I, 132 kV Kesinga feeder and one 132/33 kV transformer shall be kept on 132 kV Section-I

7. At Theruvali grid sub-station, 132 kV Section isolator is to be made open.
8. At Indravati PH, the identified unit shall be started by availing auxiliary power supply from DG set and charged the Bus-II. The DG set starting time and the output parameters shall be recorded.
9. M/s. VAL, Langigarh shall be intimated by Theruvali to remain in islanding mode of operation to avoid its unit tripping. Also Muniguda Traction will be intimated to avail feed extension.
10. At Theruvali grid sub-station, 220 kV bus-coupler breaker shall be OPENED so that only 220 kV Theruvali Ckt.-III along with Auto-I shall remain on Bus-I. 132 kV Kesinga feeder is to be charged from the supply available from AT-I, needs to be hand tripped and connected to 132kV main bus section.
11. At Indravati PH switchyard, 220 kV Theruvali Ckt.-III shall be charged.
12. At Theruvali grid sub-station, the 220 kV Bus-I shall be charged by availing power supply from Indravati Ckt.-III and subsequently Auto-I shall be charged.
13. At Theruvali grid sub-station, 132 kV Kesinga feeder shall be charged and gradually loaded.
14. At each step, Theruvali grid sub-station and Indravati PH shall record all the parameter readings such as Power Flow (both MW & MVAR), Frequency, Voltage etc.
15. The island so formed shall be synchronized with the system at Theruvali grid sub-station / Indravati PH as per the direction of SLDC.
16. All operations shall be carried out in co-ordination with SLDC.
17. The electrical parameters at different time period of operation and activity time should be recorded at Upper Indravati HPS in the format given below.

Sl. No.	Parameters	Time( )	Time( )	Time( )	Time( )	Time( )
1.	Frequency (Hz)					
2.	Load (MW)					
3.	Generator Voltage (kV)					
4.	220kV isolated Bus Voltage (kV)					
5.	Reactive Power (MVAR)					
6.	Generator Current (kA)					

7.	Power Factor (lead / lag)					
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<b>Activity</b>	<b>Time (Minutes)</b>
Time taken to start DG set after black out of Island	
Time taken to charge dead bus at Black start station	
Time taken to charge dead bus at Remote end by line charging	
Time taken to connect first load post a black out in the island	
Duration of stable island operation after successful black start and building up the of the island till synchronization with grid	
Time taken to synchronize the island with Grid	

#### **7.4 Procedure for periodic exercise of black starting Rengali HEP**

1. The 220kV line flows around Rengali and OPTCL network as a whole, to be closely monitored by SLDC.

##### **AT RENGALI PH (OHPC)**

1. 220 kV Rengali(HPS)-Rengali Switchyard Ckt.-II to be switched off from both ends.
2. All outgoing / incoming feeders i.e. TTPS, Kaniha, Rengali Switchyard Ckt-I & Station Transformer to be transferred to 220kV Bus-B except 220kV Rengali Switchyard Ckt-II, which is to be connected to Bus-A. Both the buses are to be isolated by opening the bus-coupler breaker.
3. The selected generating unit at Rengali HPS to be started up using the diesel generating set available at the power station.
4. The above unit is to be connected to the isolated Bus -A at Rengali HPS.
5. 220kV Rengali PH- Rengali Switchyard Ckt.-II to be idle charged from Rengali PH end from Bus - A.

### **AT RENGALI SWITCHYARD SUB-STATION (OPTCL)**

1. All outgoing / incoming feeders i.e. Rengali PH Ckt-I, PGCIL- I & II, Tarkera (Chandiposh), Barkot & both 220 / 33kV Transformers to be kept on 220kV Bus-A except 220kV Rengali PH Ckt-II. Both the buses are to be isolated by opening the bus-coupler breaker.
2. 220kV Bus-B is to be made free at Rengali Switchyard S/s (OPTCL). 220kV Rengali PH-Rengali Switchyard Ckt.-II, idle charged from Rengali PH is to be connected to Bus-B.
3. Both 220/33kV, 20MVA transformer load at Rengali switchyard to be transferred to Bus-B by isolating from Bus-A after getting clearance from SLDC.

### **SEQUENCE OF OPERATION:**

1. 220 kV Rengali PH-Rengali Switchyard Ckt.-2 shall be made OFF from both the ends.
2. At Rengali PH switchyard, all outgoing 220 kV feeders i.e. TTPS, Kaniha, Rengali Switchyard Ckt-I & Station Transformer shall be transferred to 220kV Bus-B.
3. At Rengali PH switchyard, 220 kV Rengali PH-Rengali Switchyard Ckt.-2 and the identified unit for black start shall be kept on 220 kV Bus-A. Both the buses are to be isolated by opening the bus-coupler breaker.
4. At Rengali Switchyard grid sub-station, all outgoing / incoming feeders i.e. Rengali PH Ckt-I, PGCIL- I & II, Tarkera (Chandiposh), Barkot & both 220 / 33kV Transformers to be kept on 220kV Bus-A.
5. At Rengali Switchyard grid sub-station, 220kV Rengali PH- Rengali Switchyard Ckt.-II & both 220/33kV, 20MVA transformers shall be transferred to Bus-B.
6. At Rengali PH, the identified unit shall be started by availing auxiliary power supply from DG set and charge the Bus-A. The DG set starting time and the output parameters shall be recorded.
7. At Rengali PH switchyard, 220 kV Rengali PH-Rengali Switchyard Ckt.-2 shall be charged.
8. At Rengali Switchyard grid sub-station, the 220 kV Bus-B shall be charged by availing power supply from Rengali PH Ckt.-II.
9. At Rengali Switchyard grid sub-station, 220/33kV, 20MVA transformers shall be charged and gradually loaded.
10. At each step, Rengali Switchyard grid sub-station and Rengali PH shall record all the parameter readings such as Power Flow (both MW & MVA<sub>r</sub>), Frequency, Voltage etc.

11. The island so formed shall be synchronized with the system at Rengali PH as per the direction of SLDC.

12. All operations shall be carried out in co-ordination with SLDC.

**Important Points:**

- Voltage of the isolated bus and reactive power generation by the unit (on primary side of GT) before and after idle-charging the 220 kV circuit as well as after connecting load are to be recorded.
- The unit is to be synchronized with the system at Rengali PH as per the direction of SLDC.
- During the exercise, SLDC shall keep record of the time of issuance of every instruction and time of actual execution of the switching operation.
- Additional data such as frequency & voltage of the MW / MVar of the unit shall also be recorded by Rengali PH / SLDC.
- The electrical parameter at different time period of operation and activity time should be recorded at Rengali HPS in the format given below.

Time--→			
Frequency (Hz)			
Load (MW)			
Generator Terminal Voltage (kV)			
220 kV Isolated Bus Voltage			
Reactive Power (Mvar)			
Generator Current (kA)			
Pf (Lead / Lag)			

<b>Activity</b>	<b>Time (Minutes)</b>
Time taken to start DG set after black out of Island	
Time taken to charge dead bus at Black start station	
Time taken to charge dead bus at Remote end by line charging	
Time taken to connect first load post a black out in the island	

Duration of stable island operation after successful black start and building up the of the island till synchronization with grid	
Time taken to synchronize the island with Grid	

## **7.5 Procedure for periodic exercise of black starting Burla HEP**

The 132kV line flows around Burla and OPTCL network as a whole, to be closely monitored by SLDC.

### **AT BURLA PH (OHPC)**

1. 132 kV Burla (HPS)-Katapalli ckt.-I to be switched off from both ends.
2. All outgoing / incoming feeders i.e. Chiplima, Lapanga I & II (Budhipadar I & II), 132kV Burla (HPS)-Katapalli ckt.-II, Sambalpur & Station Transformers to be transferred to 132kV Main Bus except 132kV Burla (HPS)-Katapalli ckt.-I, which is to be connected to 132kV Reserve Bus. Both the buses are to be isolated by opening the bus-coupler breaker.
3. The selected generating unit at Burla HPS to be started up using the Diesel Generator set available at the power station.
4. The above unit is to be connected to the isolated Reserve Bus at Burla HPS.
5. 132 kV Burla (HPS)-Katapalli ckt.-I to be idle charged from Burla PH end through Reserve Bus.

### **AT KATAPALLI SUB-STATION (OPTCL)**

2. All outgoing / incoming 132kV feeders i.e. Bargarh, Chiplima- I & II, 132kV Burla PH Ckt-II & 132 / 33kV Transformer to be kept on 132kV Main Bus except one 132kV Burla PH Ckt-I and 132kV Sambalpur Ckt. 132kV Burla PH Ckt-I and 132kV Sambalpur Ckt. are to be connected through Reserve Bus of Katapalli. Both the buses are to be isolated by opening the bus-coupler breaker.
3. 132kV Burla PH - Katapalli Ckt-I, idle charged from Burla PH will be extended up to Sambalpur Grid Sub-station.

### **AT SAMBALPUR SUB-STATION (OPTCL)**

1. 132kV Burla - Sambalpur Ckt. to be kept on 132kV Main Bus and 132kV Katapali - Sambalpur Ckt. & 132kV Sambalpur-Rairakhhol Ckt. To be kept on Reserve Bus.
2. Rairakhhol Grid Sub-station area load will be put on Burla PH through 132kV Katapali - Sambalpur Ckt. & 132kV Sambalpur-Rairakhhol Ckt. after getting clearance from SLDC.

### **AT RAIRAKHOL SUB-STATION (OPTCL)**

1. 132kV Rairakhhol-Boinda Ckt. is to be kept open at Rairakhhol end after getting clearance from SLDC.
2. 132kV Rairakhhol-Sambalpur-Katapalli Ckt. To be charged after getting clearance from SLDC.

### **SEQUENCE OF OPERATION:**

1. 132 kV Burla PH-Katapali Ckt.-I shall be made OFF from both the ends.
2. At Burla PH switchyard, all outgoing / incoming feeders i.e. Chiplima, Lapanga I & II, 132kV Burla (HPS)-Katapalli ckt.-II, Sambalpur & Station Transformers to be transferred to 132kV Main Bus except 132kV Burla (HPS)-Katapalli ckt.-I, which is to be connected to 132kV Reserve Bus. Both the buses are to be isolated by opening the bus-coupler breaker.
3. At Burla PH the identified unit for black start shall be kept on Reserve Bus.
4. At Katapali grid sub-station Switchyard, all outgoing / incoming 132kV feeders i.e. Bargarh, Chiplima- I & II, 132kV Burla PH Ckt-II & 132 / 33kV Transformer to be kept on 132kV Main Bus except one 132kV Burla PH Ckt-I and 132kV Sambalpur Ckt.
5. At Katapali grid sub-station Switchyard 132kV Burla PH Ckt-I and 132kV Sambalpur Ckt. are to be connected through Reserve Bus of Katapalli. Both the buses are to be isolated by opening the bus-coupler breaker.
6. At Sambalpur grid sub-station Switchyard, 132kV Burla - Sambalpur Ckt. to be kept on 132kV Main Bus and 132kV Katapali - Sambalpur Ckt. & 132kV Sambalpur-Rairakhhol Ckt. To be kept on Reserve Bus.
7. At Rairakhhol grid sub-station Switchyard 132kV Rairakhhol-Boinda Ckt. is to be kept open.
8. At Burlai PH, the identified unit shall be started by availing auxiliary power supply from DG set and charge the Reserve Bus. The DG set starting time and the output parameters shall be recorded.



9. At Burla PH switchyard, 132 kV Burla PH-Katapali Ckt.-I shall be charged.
10. At Katapali grid sub-station Switchyard, the Reserve Bus shall be charged by availing power supply from Burla PH Ckt.-I and power supply shall be extended to Rairakhhol grid substation through 132 kV Katapali-Sambalpur Ckt. & 132kV Sambalpur-Rairakhhol Ckt..
11. At Rairakhhol grid sub-station, 132/33kV, 12.5MVA transformers shall be charged and gradually loaded.
12. At each step, Rairakhhol grid sub-station and Burla PH shall record all the parameter readings such as Power Flow (both MW & MVAR), Frequency, Voltage etc.
13. The island so formed shall be synchronized with the system at Burla PH as per the direction of SLDC.

All operations shall be carried out in co-ordination with SLDC.

**Important Points:**

- Voltage of the isolated bus and reactive power generation by the unit (on primary side of GT) before and after idle-charging the 220 kV circuit as well as after connecting load are to be recorded.
- The unit is to be synchronized with the system at Burla PH as per the direction of SLDC.
- During the exercise, SLDC shall keep record of the time of issuance of every instruction and time of actual execution of the switching operation.
- Additional data such as frequency & voltage of the MW / MVAR of the unit shall also be recorded by Burla PH / SLDC.
- The electrical parameter at different time period of operation and activity time should be recorded at Burla HPS in the format given below.

Sl. No.	Parameters	Time	Time	Time	Time	Time
1.	Frequency (Hz)					
2.	Load (MW)					
3.	Generator Voltage (kV)					

4.	220kV isolated Bus Voltage (kV)					
5.	Reactive Power (MVA <sub>r</sub> )					
6.	Generator Current (kA)					
7.	Power Factor (lead / lag)					

<b>Activity</b>	<b>Time (Minutes)</b>
Time taken to start DG set after black out of Island	
Time taken to charge dead bus at Black start station	
Time taken to charge dead bus at Remote end by line charging	
Time taken to connect first load post a black out in the island	
Duration of stable island operation after successful black start and building up the of the island till synchronization with grid	
Time taken to synchronize the island with Grid	