IEEE HVDC-FACTS SUBCOMMITTEE MEETING, AUGUST 7, 2019 :: ATLANTA, USA

800 kV HVDC Projects in India

NEA800 and RP800 – by ABB

Abhay Kumar

North-East Agra (NEA800)

NEA800: Over-view

Customer/Project

- POWERGRID Corporation of India Ltd, India
- Development of renewable hydro power
  1730 km from load centre
- Low Losses (~6%)
- Compact – Minimum Right of Way
- To serve more than 90 Million people

Scope

- 6000 MW ±800 kV HVDC Bulk power transmission from NE into Agra - TURNKEY
- 33% Continuous overload i.e. 8000 MW dc power
- Three station Multi-terminal (4 parallel terminals)

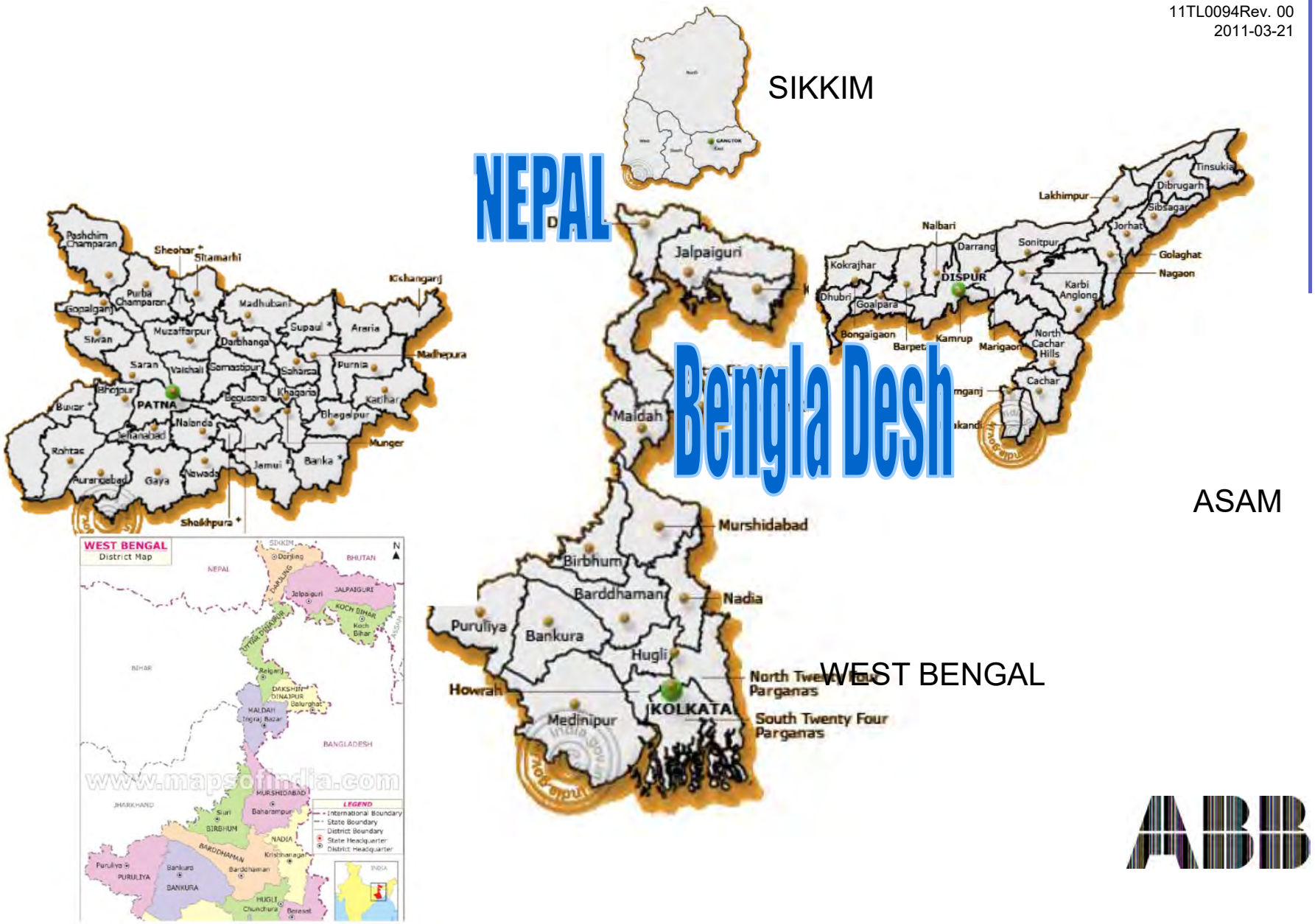
Status

- In Commercial Operation (2016/2017)

NEA800: What was/is special?

- Largest rating ever of a Converter, 2000 MW (x4 = 8000 MW)
- Highest voltage over a converter, 800 kV
- India's first 800 kVdc Transmission link
- Multi terminal operation first with 800 kV
- First 800 kV indoor dc yard 77x77x38m, largest ever
- Longest transmission in India, 1775 km
- Three electrodes rated 5000 A
- River transport of Transformers
- 800 kV Converter transformers made in two Indian units
- Direct communication between Stations (OPGW on DC Line)

Around Chicken Neck



QUIZ

- Highest rainfall area in the world?

Answer

- Cherapunji - Situated at a distance of 55 km from Shillong in Meghalaya, the height of Cherapunji is 4456 ft. (1358 m).
- The total rainfall of the region is around 500 inches (around 13 meters);
- Previously, Cherapunji was the highest rainfall area in the world, now it has shifted to Mousingram, 12 kms from Cherapunji.

Cherapunji

Close to Middle Station

Darjeeling Toy Train (July 1881) is one of the most famous narrow (2 feet) gauge trains.

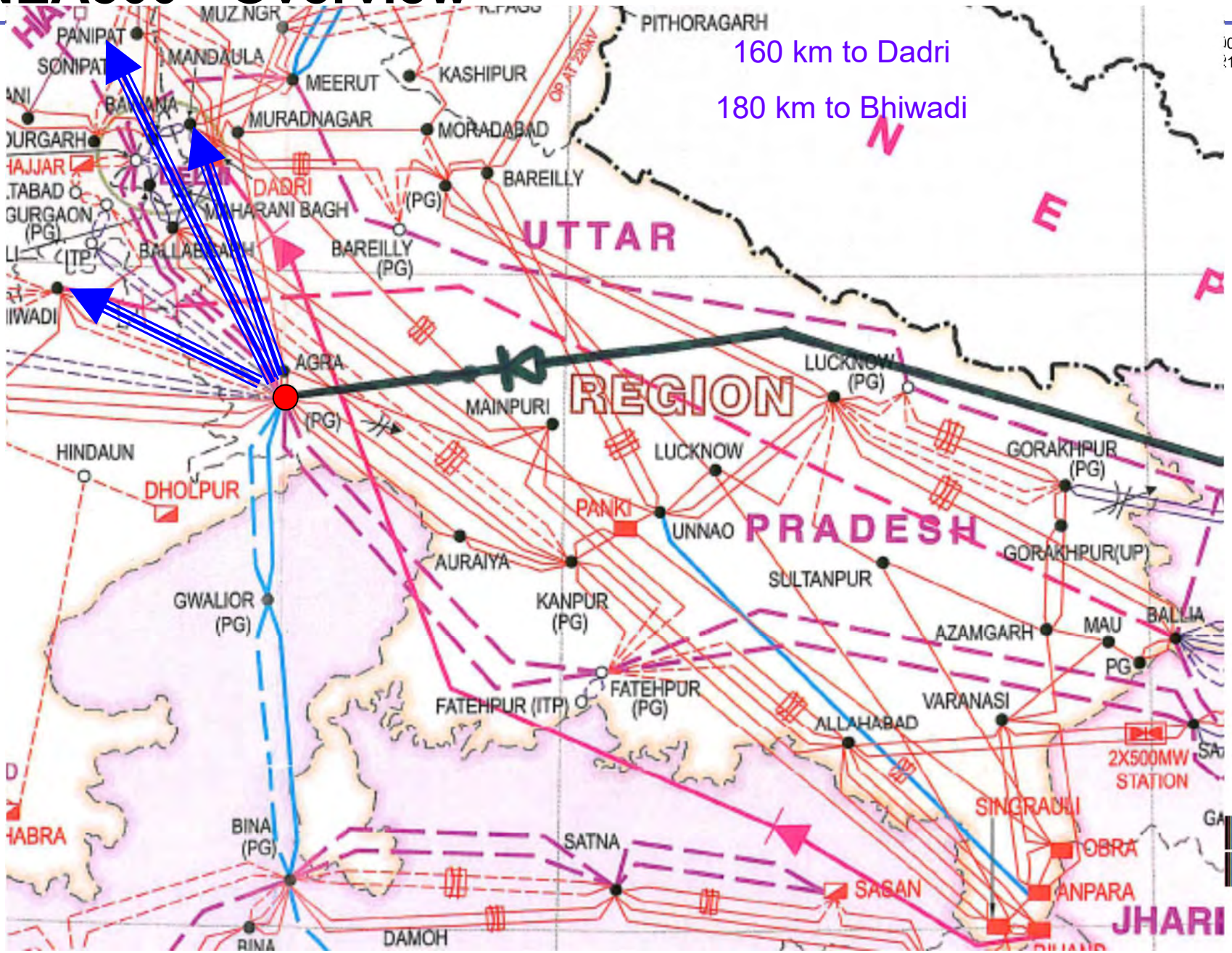
Ghoom (7407 ft/2260 m) the highest point of the journey

http://www.darjnet.com/darjeeling/darjeeling/travel/train/train.htm

Taj Mahal, ~ 15 km away from Agra site

NEA800 - Overview

NEA800 - Overview



NEA800 - Overview

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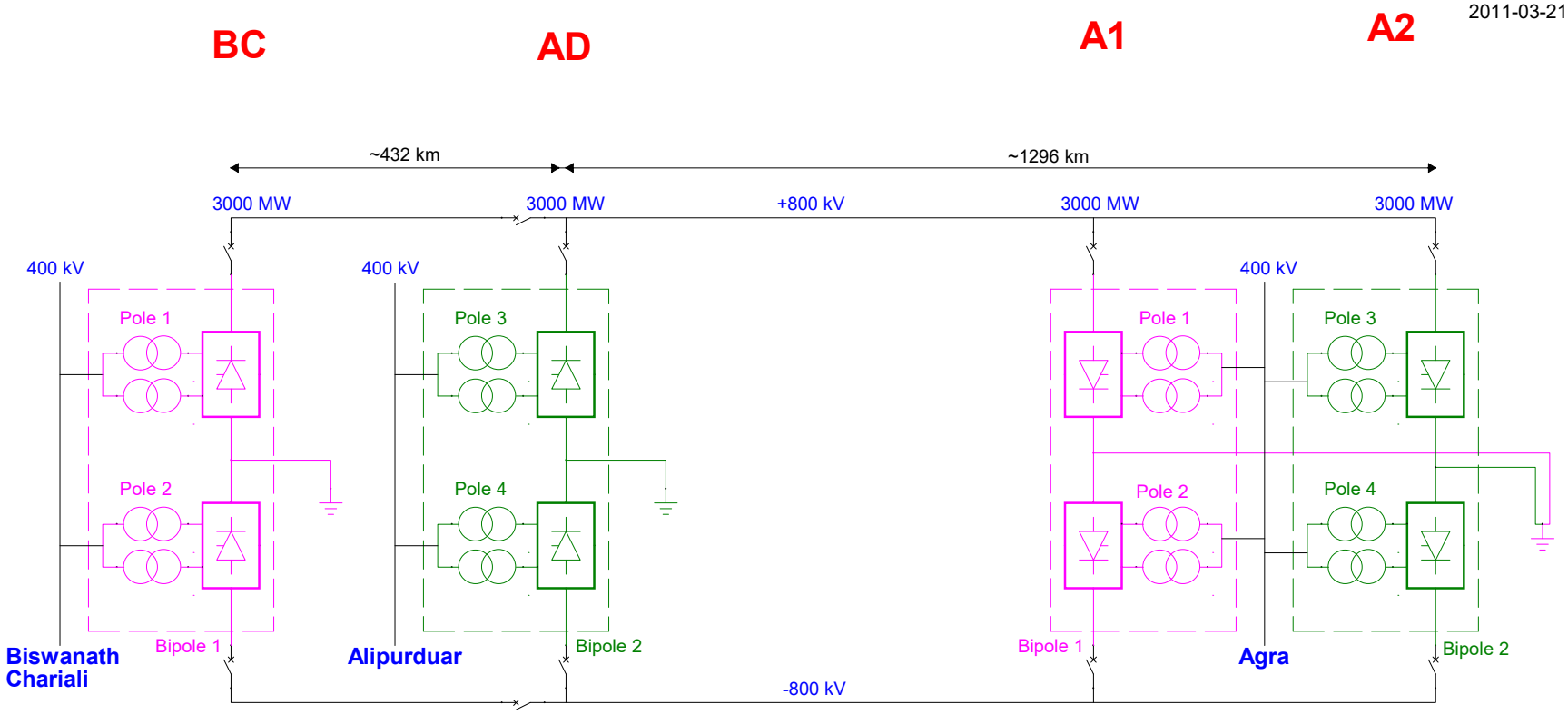
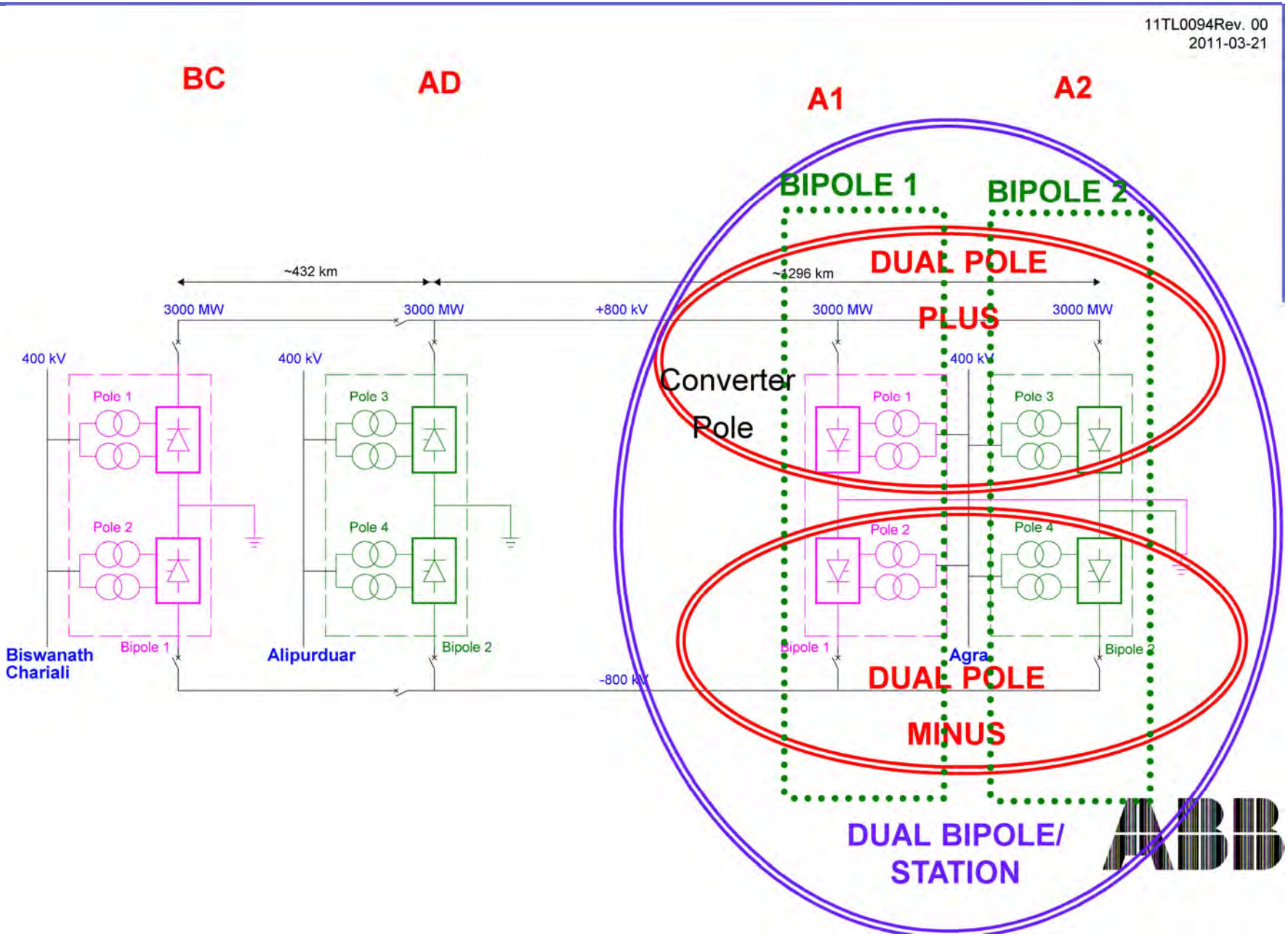


FIRST MULTI-TERMINAL AT 800 kV

Station BC & AD are in a synchronous network. Agra may OR may NOT be in same network.

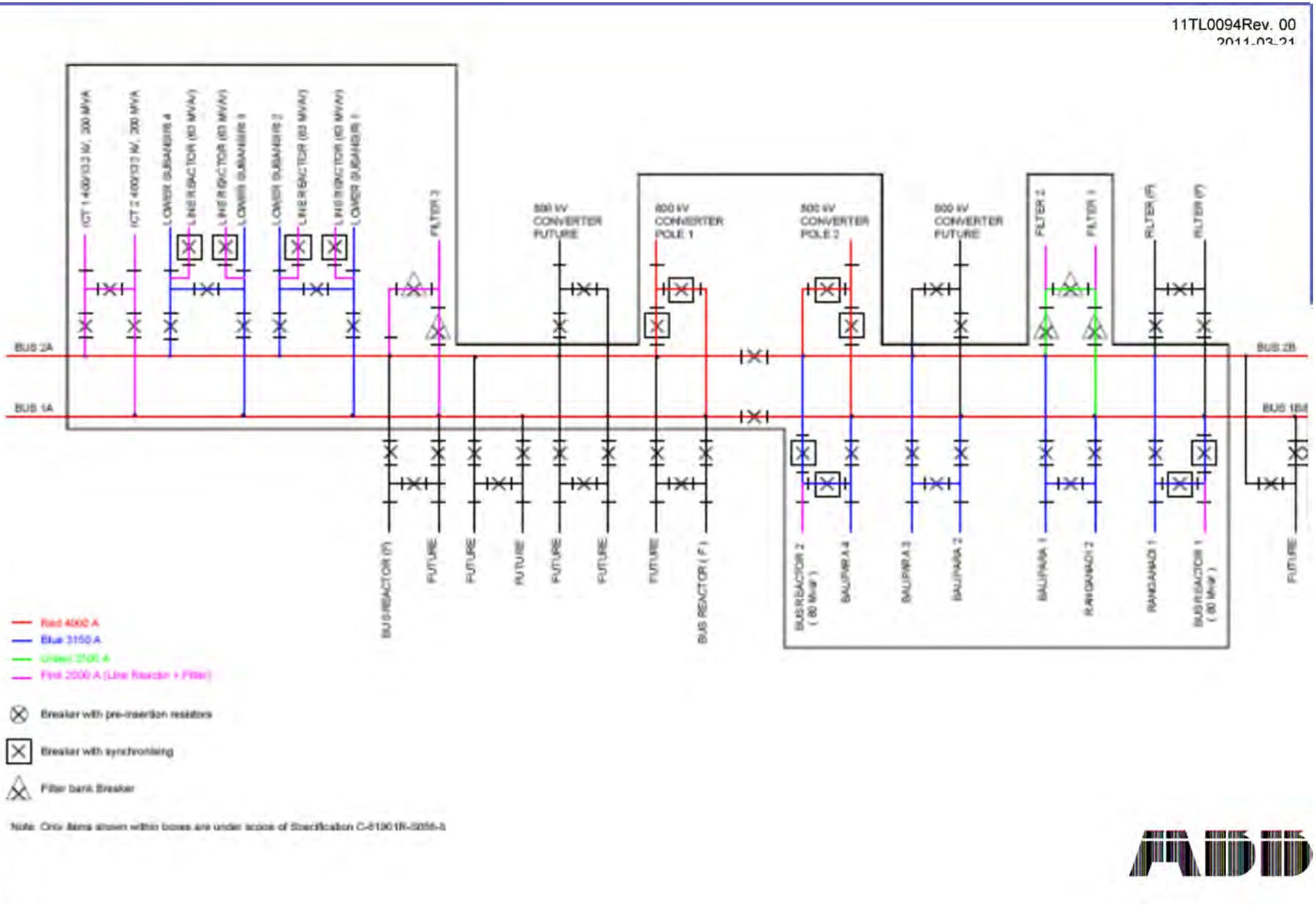
NEA800 – Overview/Naming



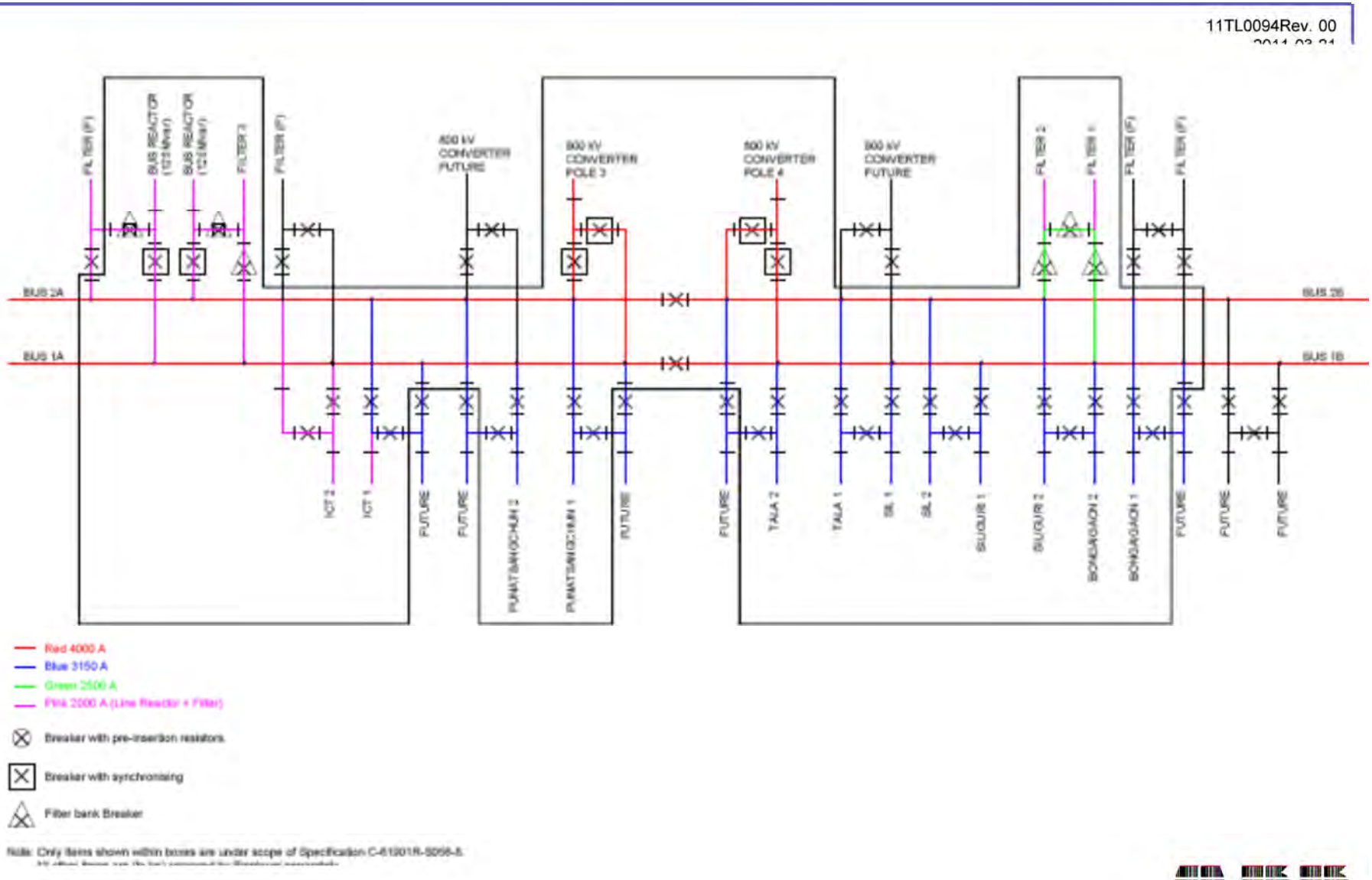
NE to Agra Technical summary

- 800 kVdc technology
- multi-terminal
- 4 terminals at Three Stations
  - Two 3000 MW Stations in the North-East 432 km apart
  - Two 3000 MW Terminals in parallel at Agra
- Multi-infeed into Agra
- Embedded HVDC (Parallel AC Lines)
- Total line length ~~1728 km (432 + 1296 km)~~ Now 1775 km
- 33% continuous overload i.e. 8000 MW in total (largest rating ever)
- Transformers
  - 300 MVA, 800 kV, 24 plus 6 spares (2 of each type at each station)
  - 300 MVA, 400 kV, 24 plus 6 spares
- AC substation included in package (plus HVDC Bays)

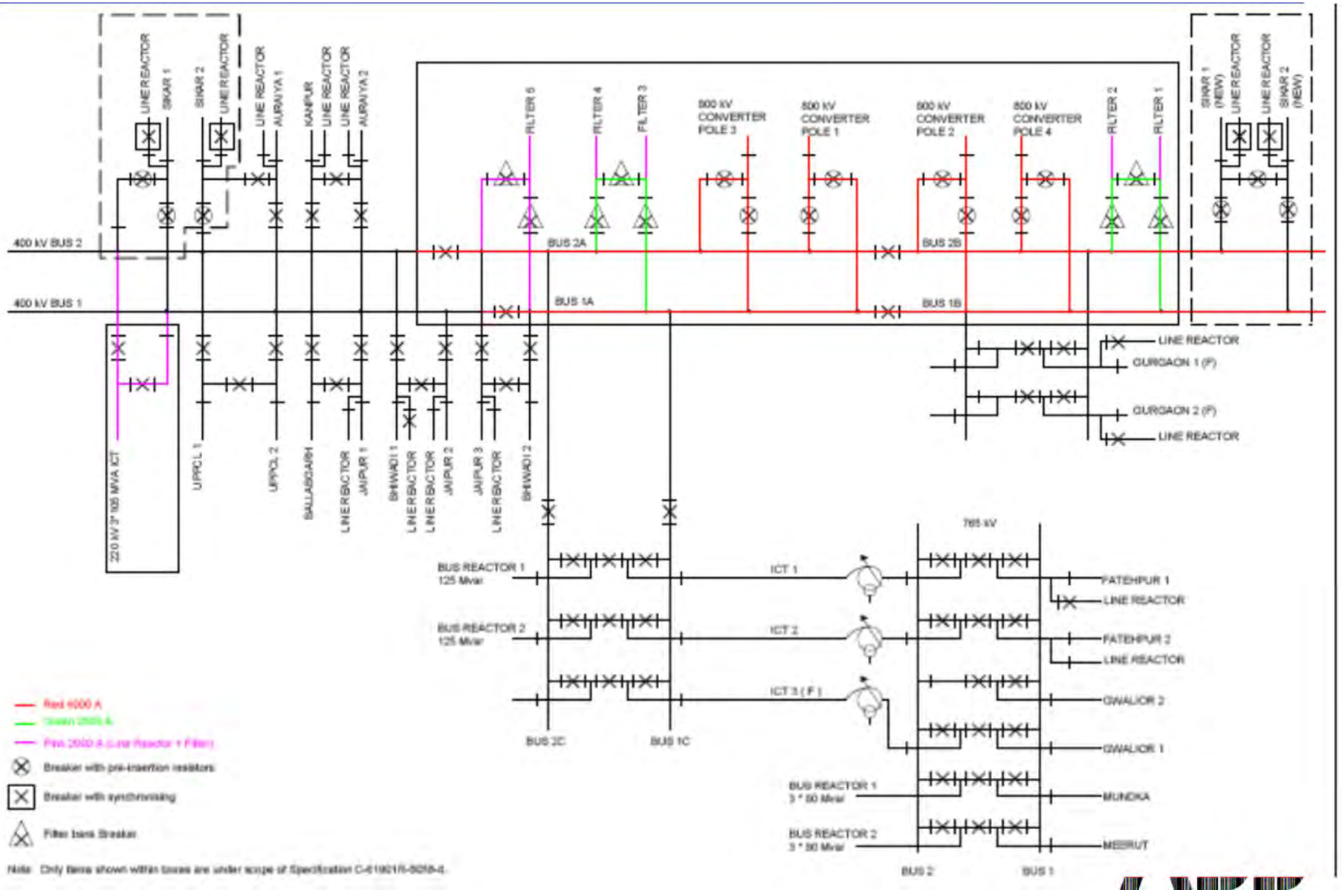
Biswanath Chariali



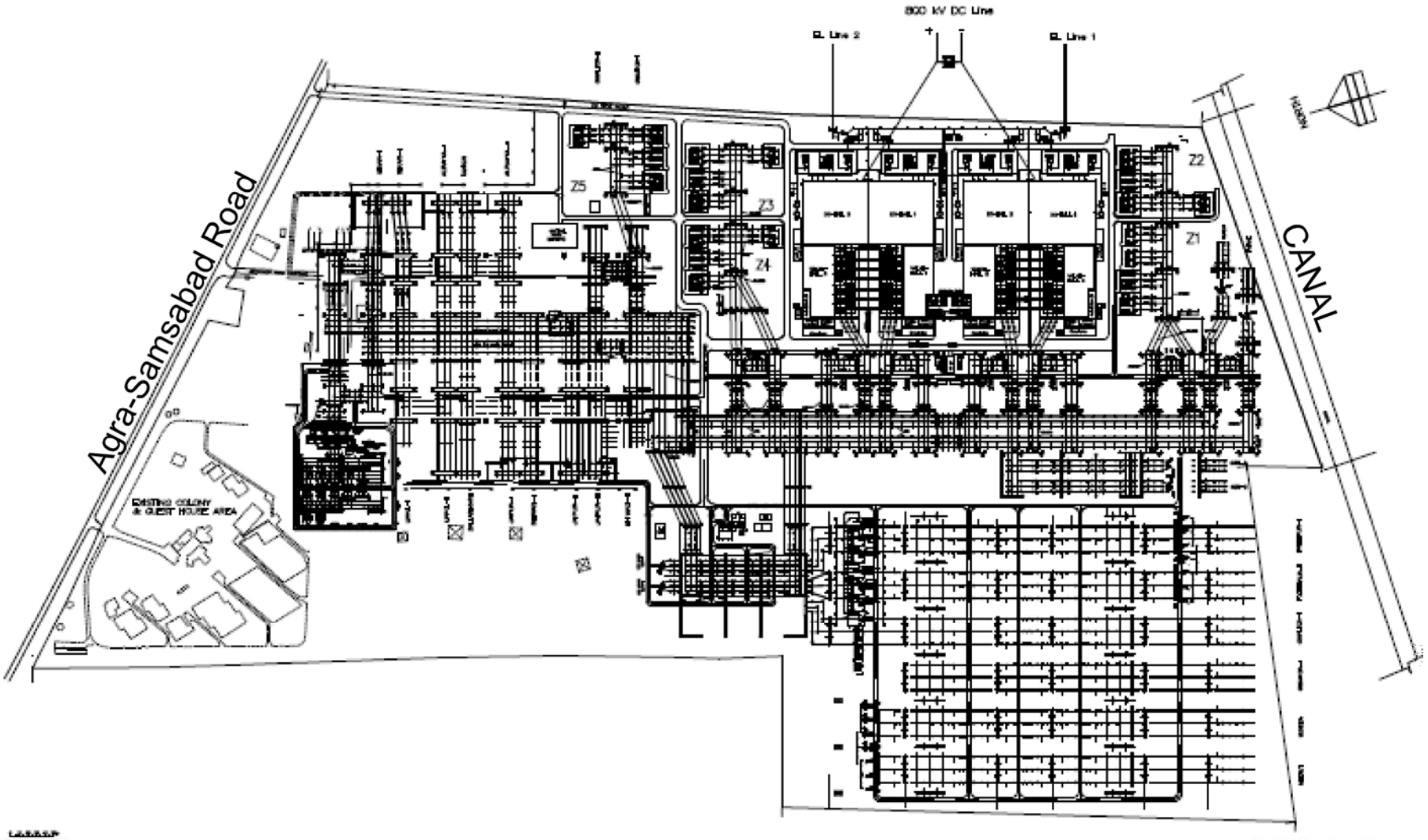
Alipurduar



Agra



NEA800 - Agra



NEA800 – Indoor DC Hall at Agra

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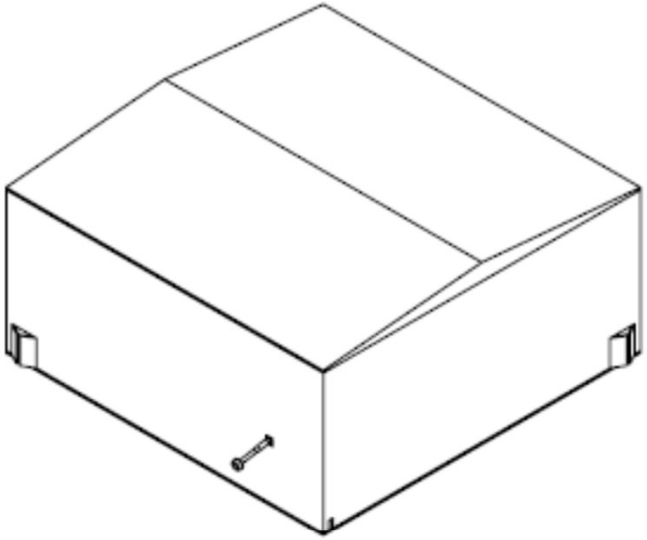
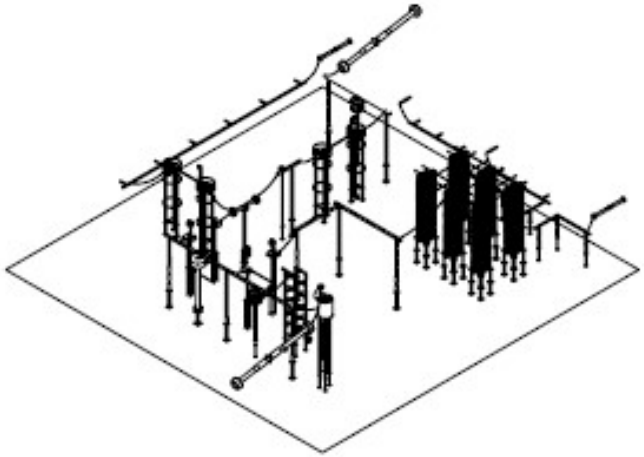
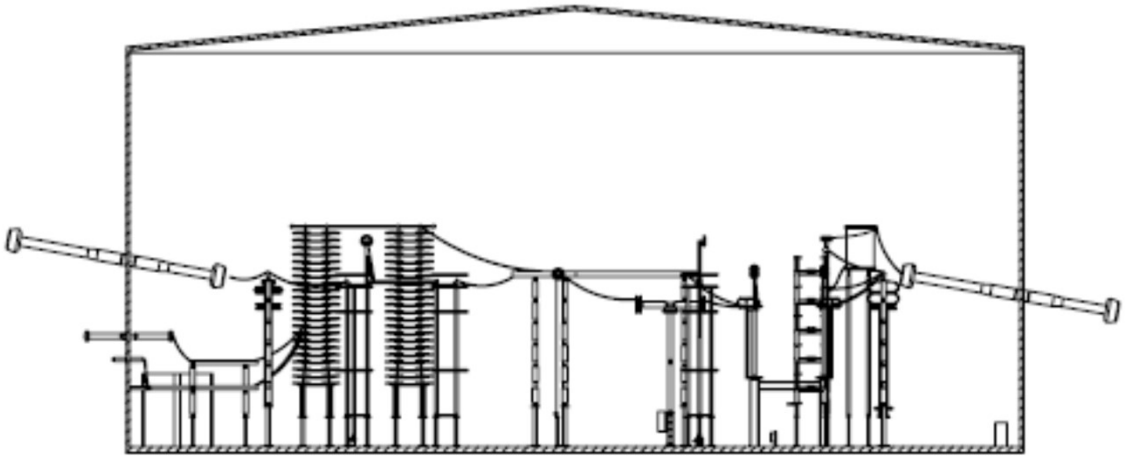
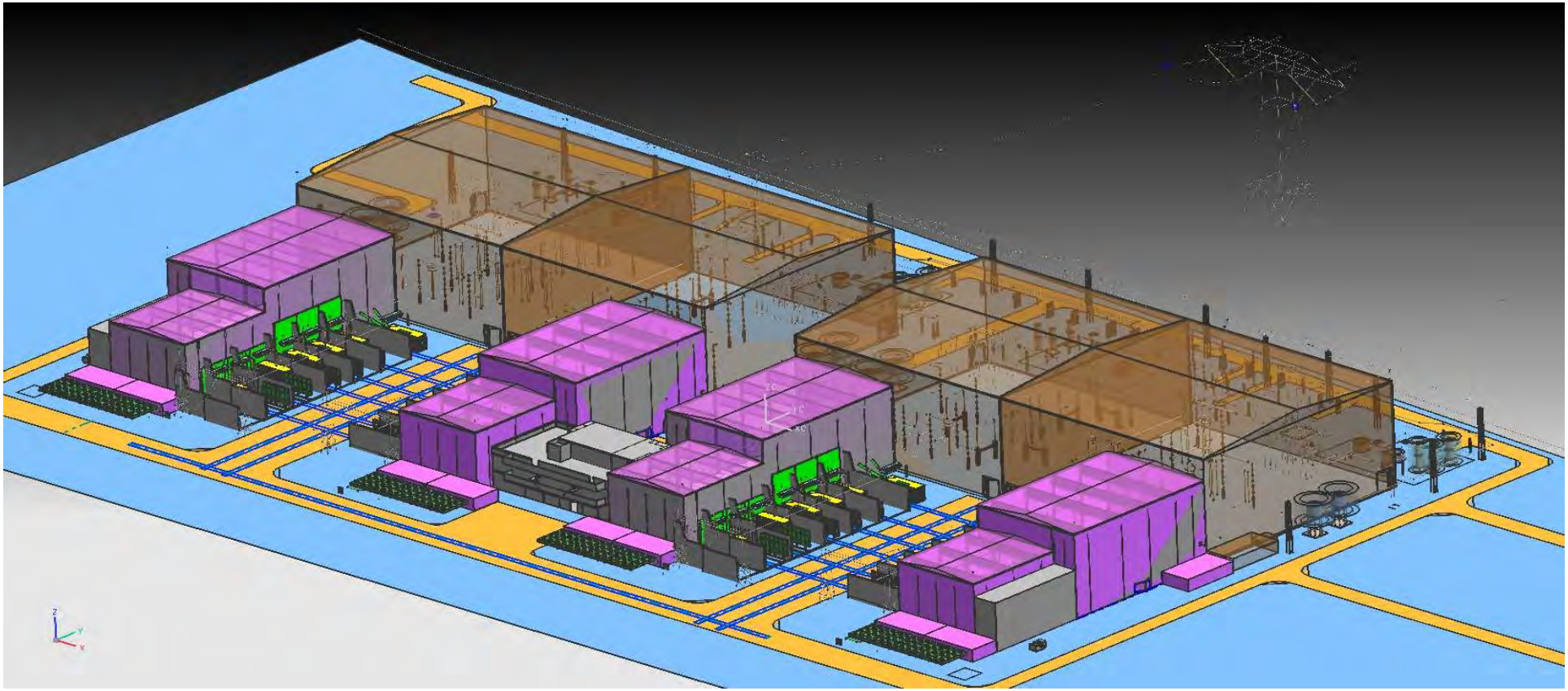






Uven is too small !

North East to Agra, Agra 3D Layout

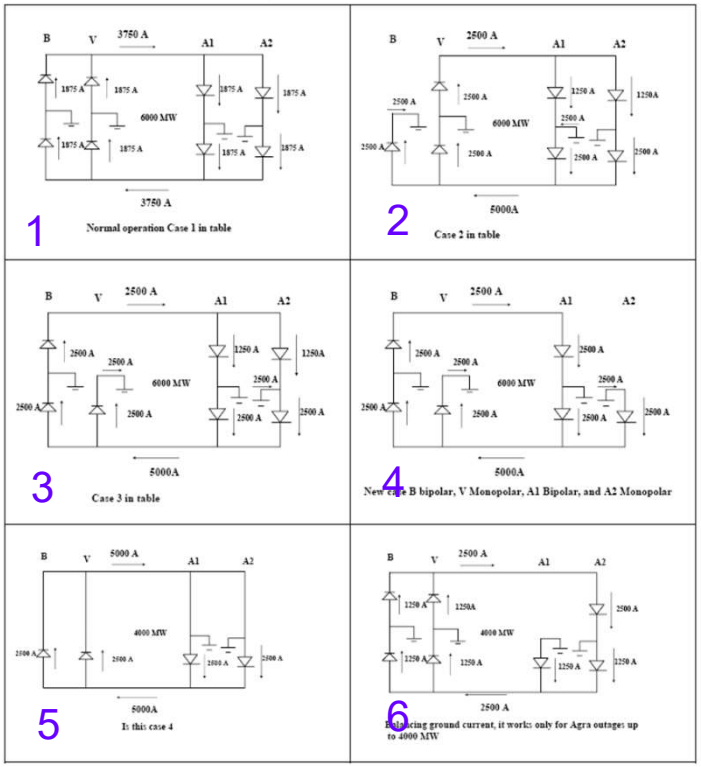


- Each Valve hall 80 x 35 x 25 m (Height)
- Each Indoor DC Hall 77 x 77 x 38 m (Height)

Technical Prespective – Different than China

- One 800 kV Converter
- Multi-terminal
- Many operating Modes
- Indoor & Outdoor DC yards

Some of the operating conditions are mentioned below:



B: Biswanath Chariali V: Bidhan Nagar A1 A2: Agra Bipole 1 & 2

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S.No	Multi-terminal Configuration	Biswanath Chariali **Rectifier**	Bidhan Nagar **Rectifier**	Agra **Inverter**	Power Transmission Capacity MW	Max Ground Current Amp
1.	Bipolar	Bipolar	Bipolar	Bipolar	6000	Nil
2.	Bipolar-Hybrid	Monopolar Ground Return	Bipolar	Bipolar	6000	2500
3.	Bipolar-Hybrid	Bipolar	Monopolar Ground Return	Bipolar	6000	2500
4.	Monopolar -Metallic	Monopolar-Metallic	Monopolar -Metallic	Monopolar-Metallic	4000	Nil
5.	Monopolar - Ground	Monopolar-Ground	Monopolar - Ground	Monopolar- Ground	4000	5000
6.	-	Bipolar	-	Bipolar	3000/4000 *	Nil
7.	-	-	Bipolar	Bipolar	3000/4000 *	Nil
8.	-	Monopolar Ground Return	-	Monopolar- Ground Return #	2000	2500
9.	-	-	Monopolar Ground Return	Monopolar Ground Return #	2000	2500
10.	-	Monopolar Metallic	-	Monopolar Metallic #	2000	Nil
11.	-	-	Monopolar Metallic	Monopolar Metallic #	2000	Nil

Either one converter in 1.33 pu (Continuous) or two converter in parallel shall share 1000 MW each.

- Converters operating at 1.33 pu (Continuous) rating.

Technical Prespective – Configurations ~32

See 08NEA0068

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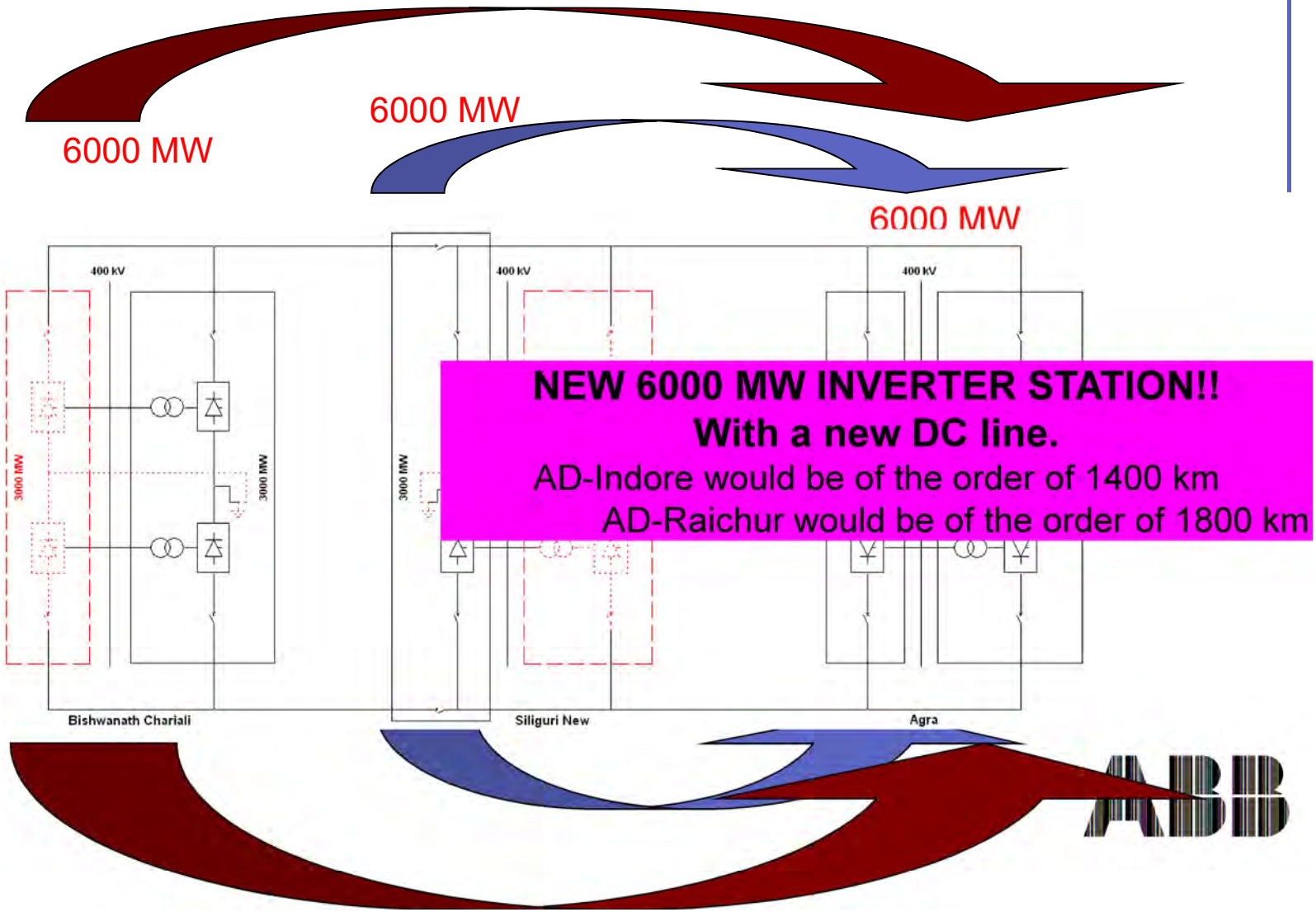
No.	S.No	Fig. No.	Multi-terminal Configuration	Biswanath Chariali **Rectifier**	Siliguri (New) **Rectifier**	Agra 1(2) **Inverter**	Agra 2(1) **Inverter**	Link Capacity MW	Ground Current Amp
1.	1	1	Bipolar	Bipolar	Bipolar	Bipolar	Bipolar	6000 (8000)	Nil
2.	1A	6	Bipolar-Hybrid	Bipolar	Bipolar	Bipolar	Monopolar Ground	4000	Nil
3.	2	2	Bipolar-Hybrid	Monopolar Ground	Bipolar	Bipolar	Bipolar	6000	2500
4.	2A	4type	Bipolar-Hybrid	Monopolar Ground	Bipolar	Bipolar	Monopolar Ground	6000	2500
5.	3	3	Bipolar-Hybrid	Bipolar	Monopolar Ground	Bipolar	Bipolar	6000	2500
6.	3A	4	Bipolar-Hybrid	Bipolar	Monopolar Ground	Bipolar	Monopolar Ground	6000	2500
7.	4	5	Monopolar Metallic	Monopolar Metallic	Monopolar-Metallic	Monopolar-Metallic	Monopolar Metallic	4000	Nil
8.	5		Monopolar Ground	Monopolar Ground	Monopolar- Ground	Monopolar Ground	Monopolar Ground	4000	5000
9.	6		-	Bipolar	-	Bipolar	-	4000	Nil
10.	6A			Bipolar	-	Bipolar	Bipolar	4000	Nil
11.	6B	6type		Bipolar	-	Bipolar	Monopolar Ground	4000	Nil
12.	7		-	-	Bipolar	Bipolar	-	4000	Nil
13.	7A			-	Bipolar	Bipolar	Bipolar	4000	Nil
14.	7B	6type		-	Bipolar	Bipolar	Monopolar Ground	4000	Nil
15.	8		-	Monopolar Ground	-	Monopolar Ground	-	2000	2500
16.	8A		-	Monopolar Ground	-	Monopolar- Ground	Monopolar Ground	2000	2500
17.	9		-	-	Monopolar Ground	Monopolar Ground	-	2000	2500
18.	9A		-	-	Monopolar Ground	Monopolar Ground	Monopolar Ground	2000	2500
19.	10		-	Monopolar Metallic	-	Monopolar Metallic	-	2000	Nil
20.	10A		-	Monopolar Metallic	-	Monopolar Metallic	Monopolar Metallic	2000	Nil
21.	11		-	-	Monopolar Metallic	Monopolar Metallic	-	2000	Nil
22.	11A		-	-	Monopolar Metallic	Monopolar Metallic	Monopolar Metallic	2000	Nil

Designed for

- Plan to include for another 6000 MW!



NEA800
Double Valves - Valve type testing

- 48 Double Valves each 9 m, 13 tonnes
- Valve hall 80 x 35 meters and 25 meters high

NEA800
Converter transformer

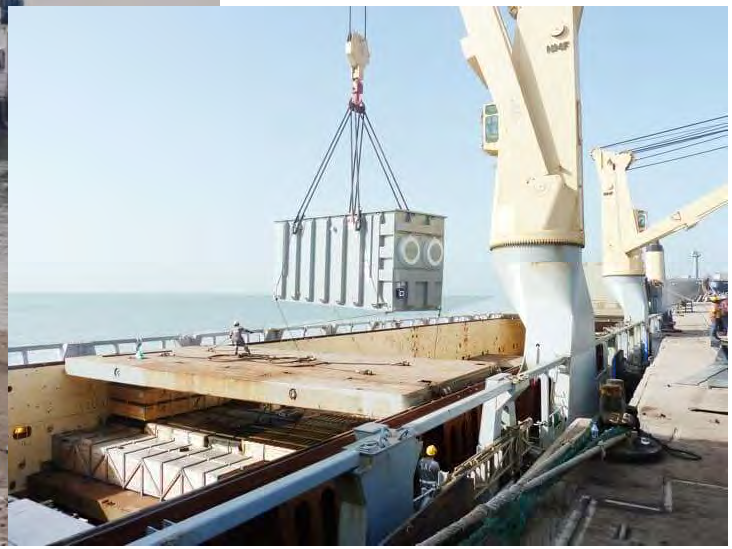
Numbers
- 30 pc 400 kV DC
- 30 pc 800 kV DC

Dimensions:
- Length 13 m
- Width 4 m
- Height 5.0 m
- Weight 510 tonnes

NEA800
Smoothing Reactors (Agra), DC Capacitors (BNC)

NEA800
River Transport

▪Transformer under unloading at the jetty



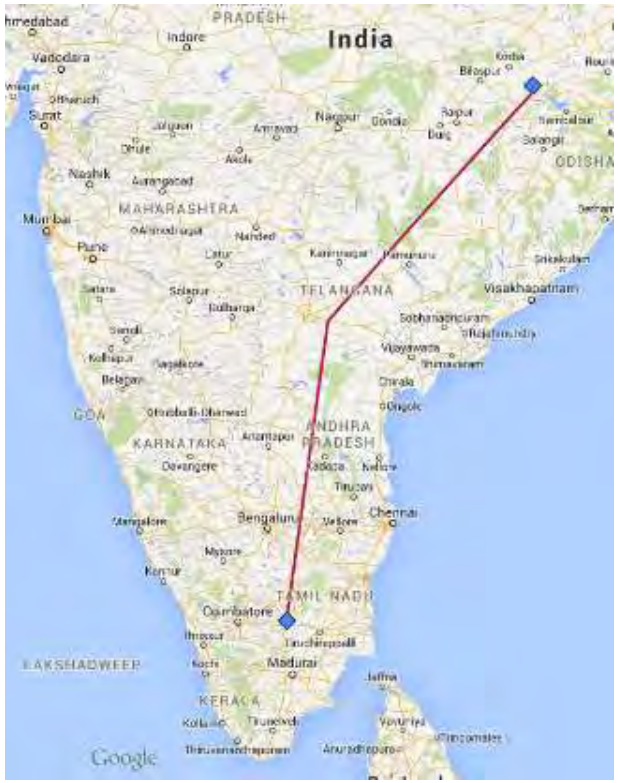
▪Transformer under loading at the port

NEA800
Road Transport

Transport to APD of 800 kV transformer on girder bridge over a by pass (temporary bridge)

Power and productivity
for a better world™

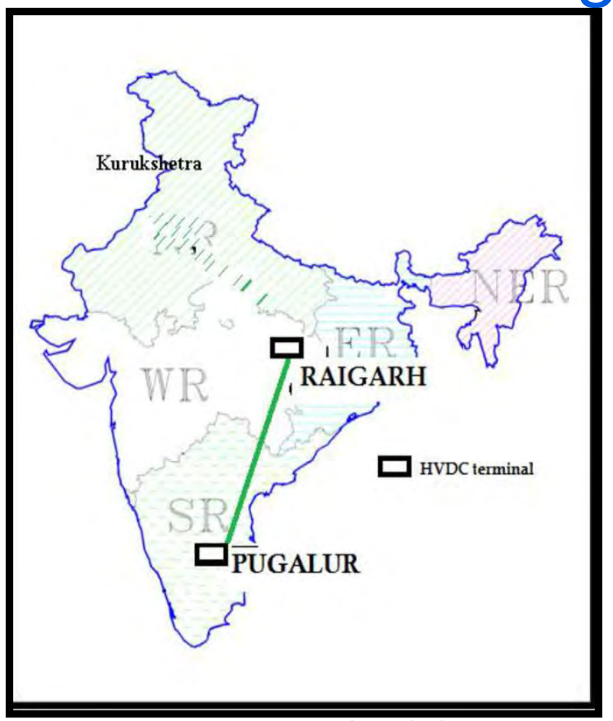
Project Overview
Raigarh-Pugalur (RP800)



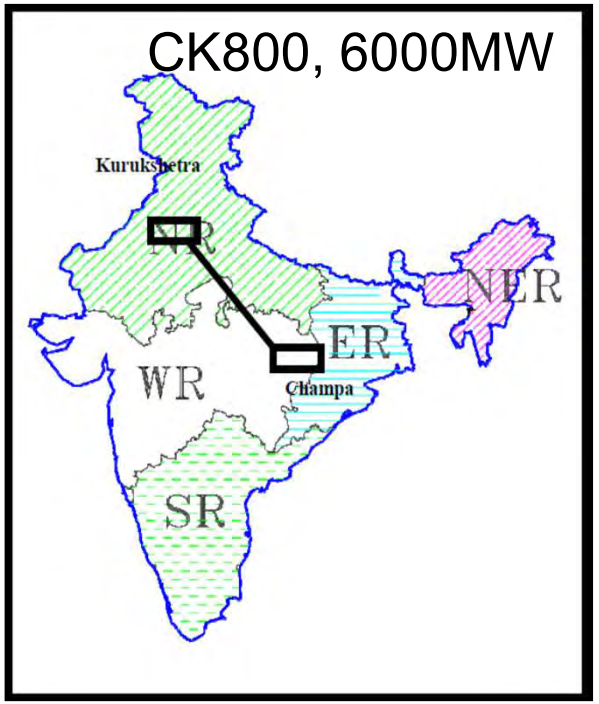
Project Name	▪ ± 800 KV,6000 MW HVDC terminals associated with HVDC Bipole link between Western region (Raigarh, Chattisgarh) and Southern region (Pugalur, Tamil Nadu)-North Trichur (Kerala)
Project description	▪ HVDC Classic Double bipole 800 kV, 6 000 MW
Customer	▪ POWERGRID Corporation of India Ltd
Timing	▪ 2019/2020
Strategic Rationale	▪ Increased demand Power in southern India

RP800

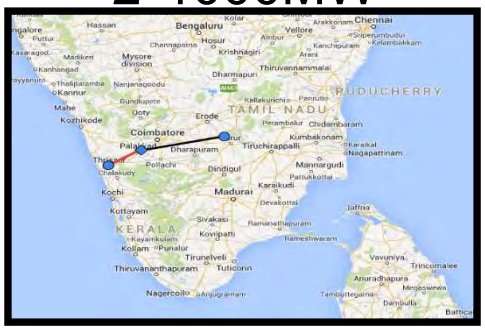
Other HVDC links in the surroundings



CK800, 6000MW



PT300 or PK2000, 2*1000MW



Talcher-Kolar, 2500MW

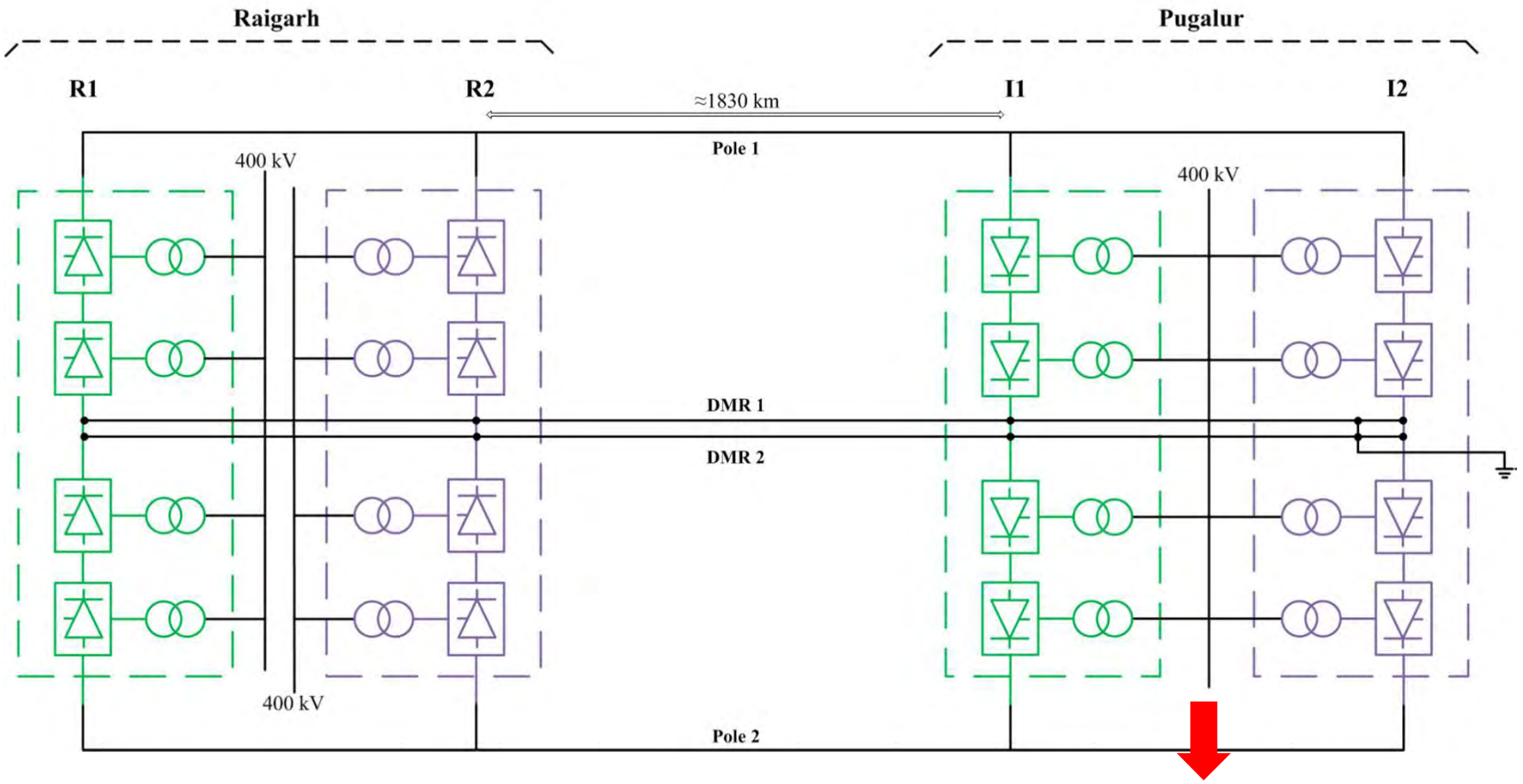
Vizag, BtB 2*500MW

RP800
Main Data

±800, 6000MW Raigarh – Pugalur HVDC Terminals (**RP800**)

- Double Bipole, Classic 6000 MW, ±800kV
- Overhead Lines ~1830 km, Dedicated Metallic Return
- Scope - Turn Key delivery
  - Two bipoles in parallel at Raigarh and at Pugalur
  - 400 kV GIS Switchyard equipment
  - 400 kV AIS filter sub bank equipment
  - Repeater Stations and Fiber Telecom Equipment

RP800
Overview



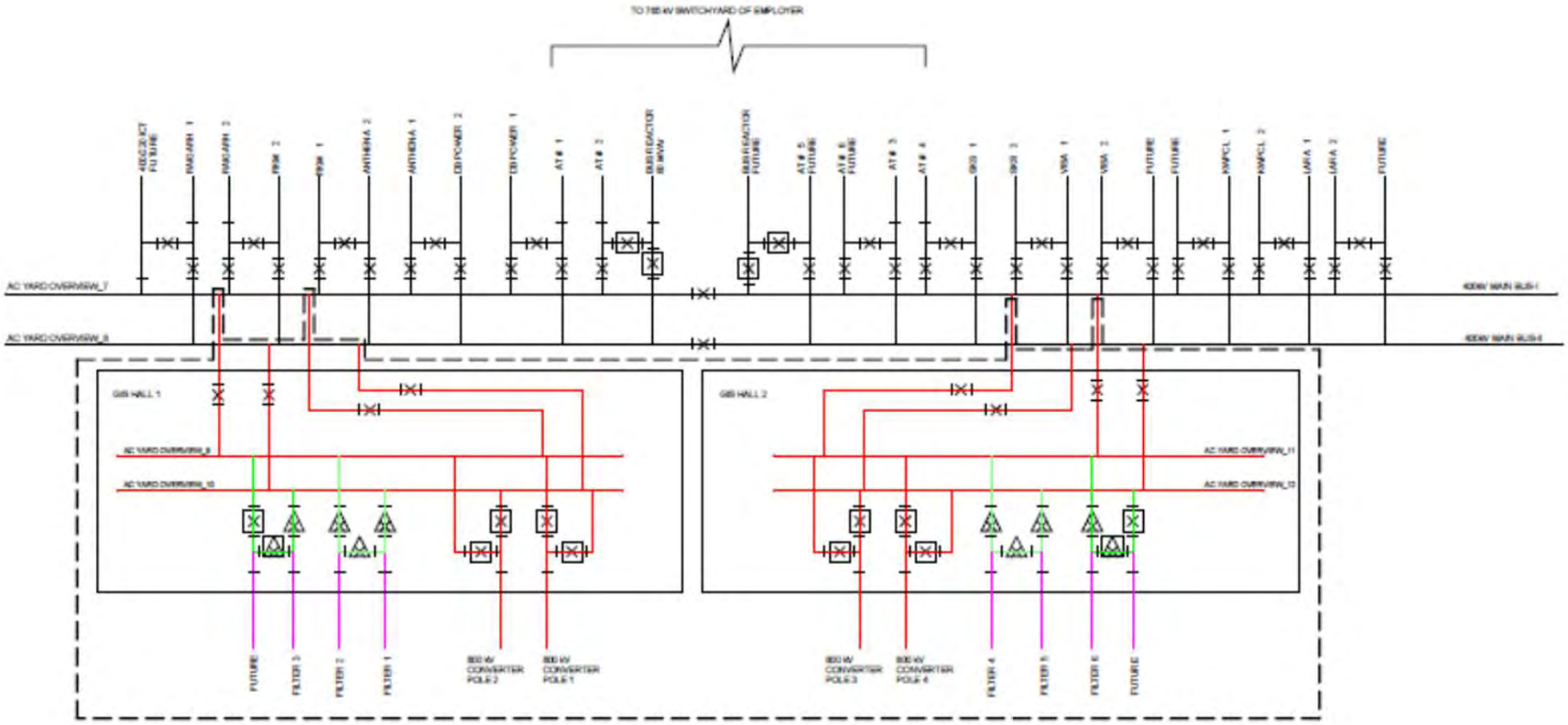
RP800
Salient Features

- Line is rated for 1.1 * 6000 MW at low ambient temperature
- The converters have 20% overload - 30 min, 10% overload – 2h, at maximum ambient temperature (and 10% continuous overload at low ambient temperature). 33% overload – 5 sec.
- 800 kV, Single 12 pulse converters
- Two 3000 MW rectifiers, in Raigarh station but with split ac network.
- Two parallel inverters at receiving station, Pugalur
- Dedicated metallic return (DMR), no electrodes
- Reduced voltage operation capability at 640 kV
- (Connection to VSC converters, Pugalur Trichur, 2*1000MW, in Pugalur station)
- Innovative layout - Five ground levels in Pugalur, 16 m height difference
- May be synchronous or asynchronous
- Reverse power possible

Paper on RP800 in B4 Colloquium/Johannesburg –
Design considerations for ±800kV, 6000MW Raigarh-Pugalur HVDC

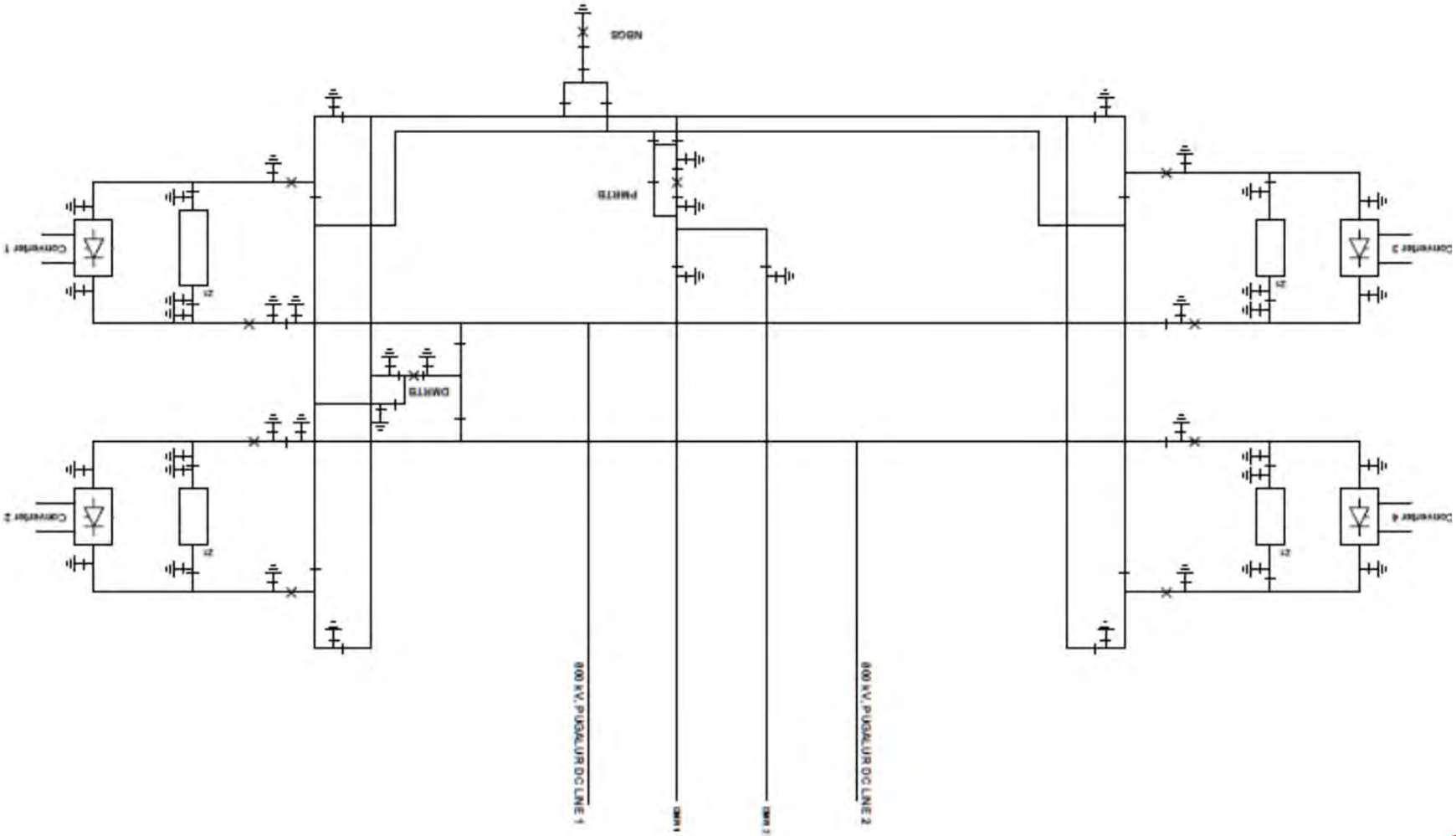
RP800
Raigarh SLD

- Split ac networks in Raigarh
  - Separate RPC's
  - Different ac voltages

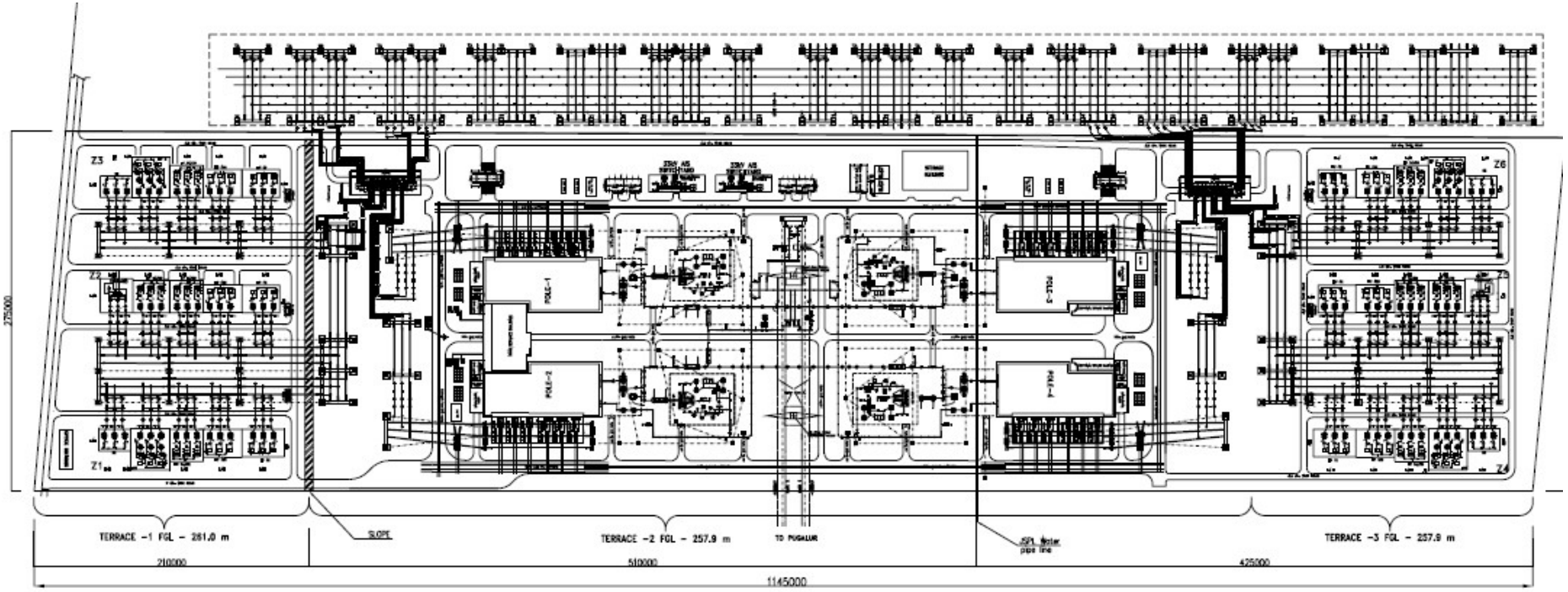


RP800
Raigarh

- Two DMR's in parallel, can only be separated when DMR carries no current (disconnectors)
- In monopolar operation DMR and PMR shall normally be connected in parallel

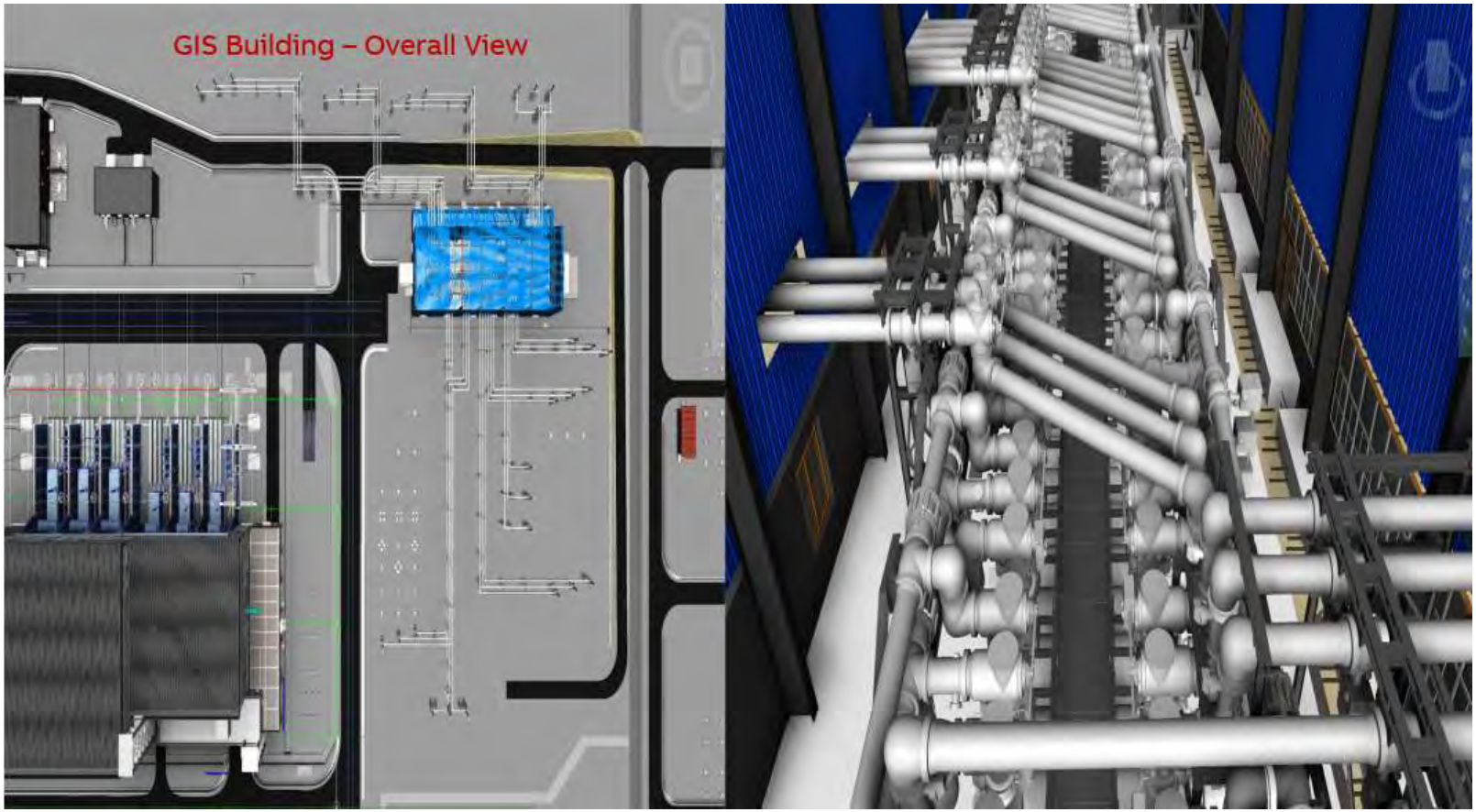


Raigarh

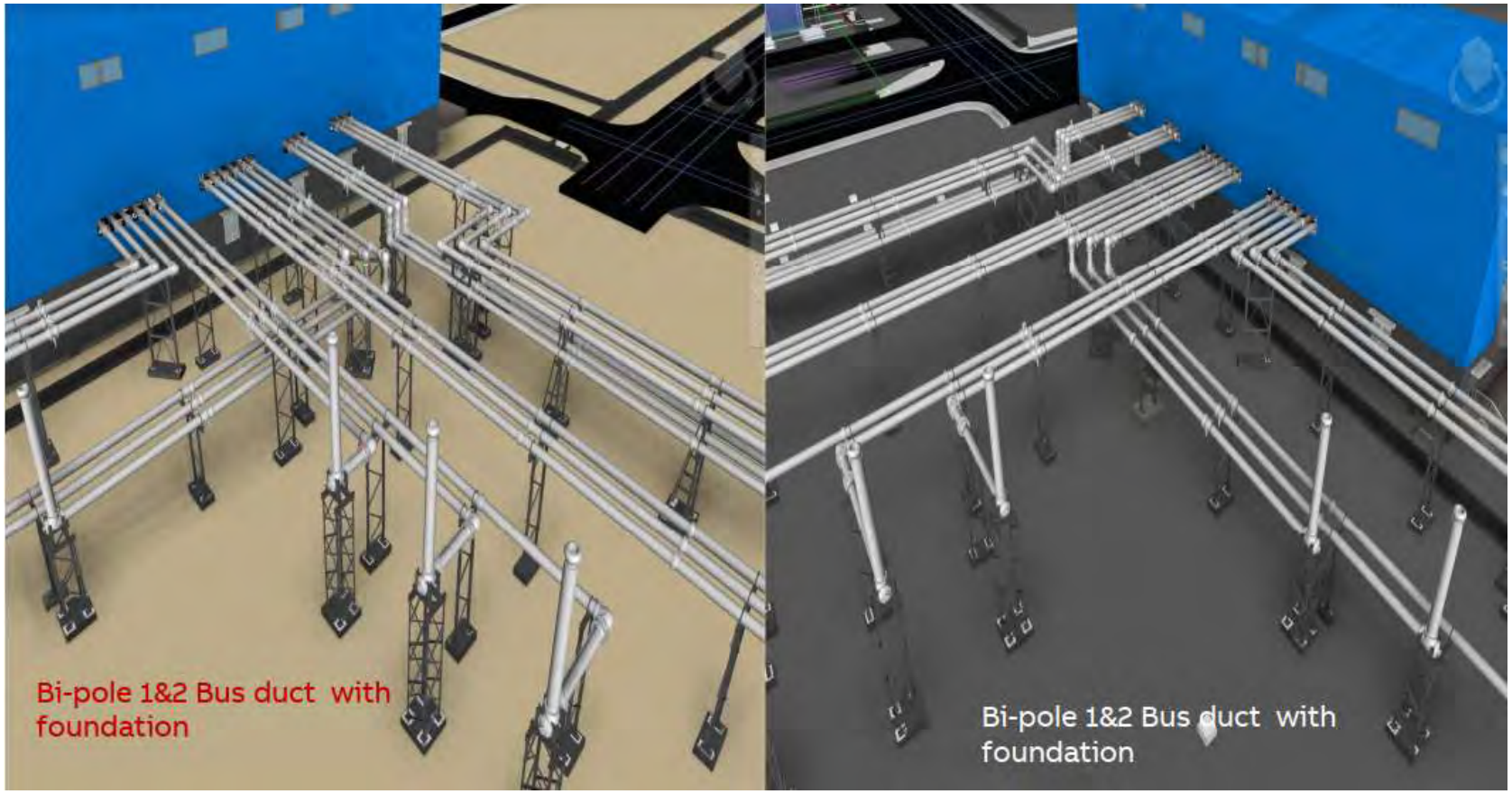


Brown Field Station (Existing 765/400 kV Sub station)

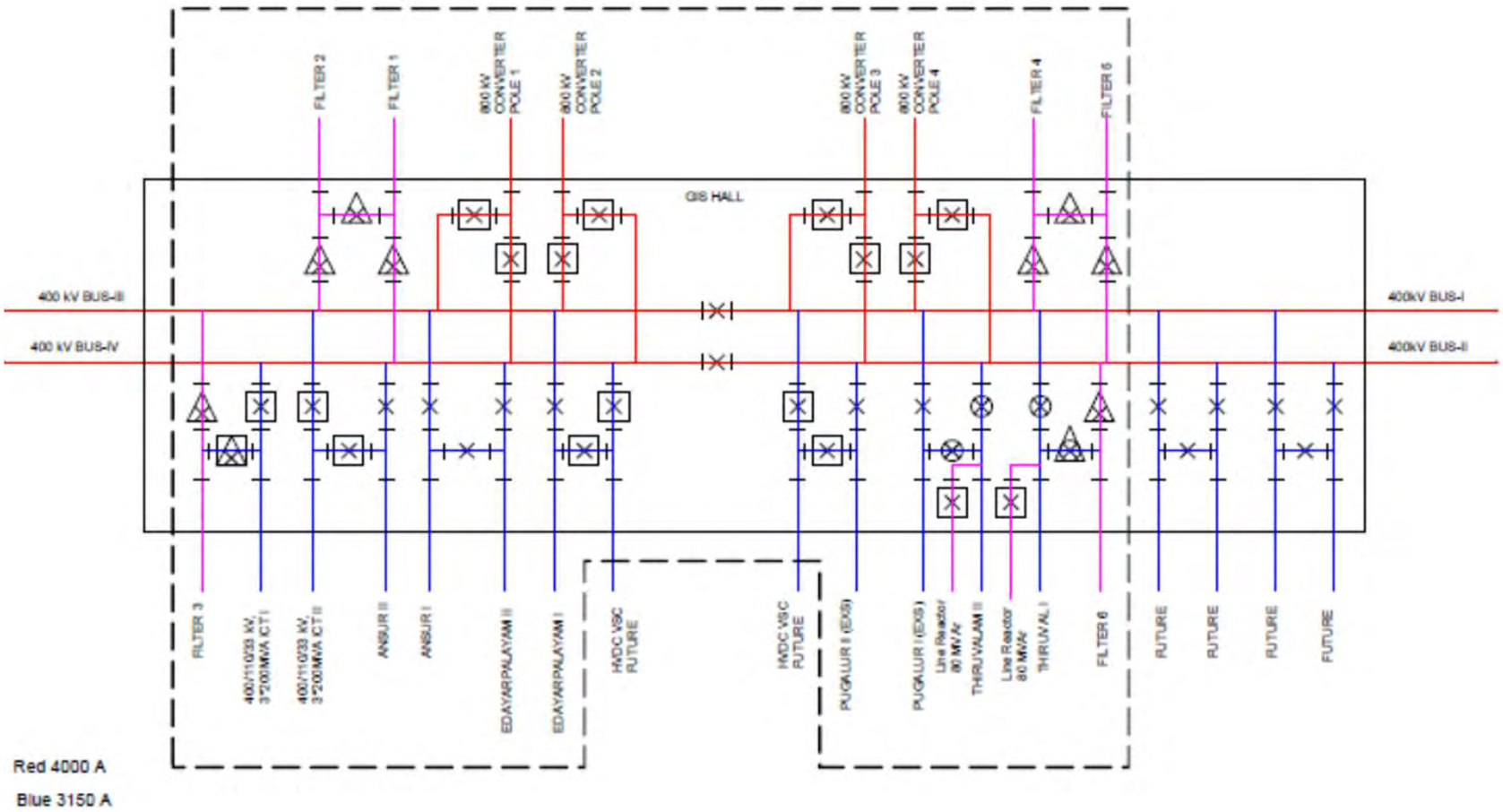
Raigarh GIS



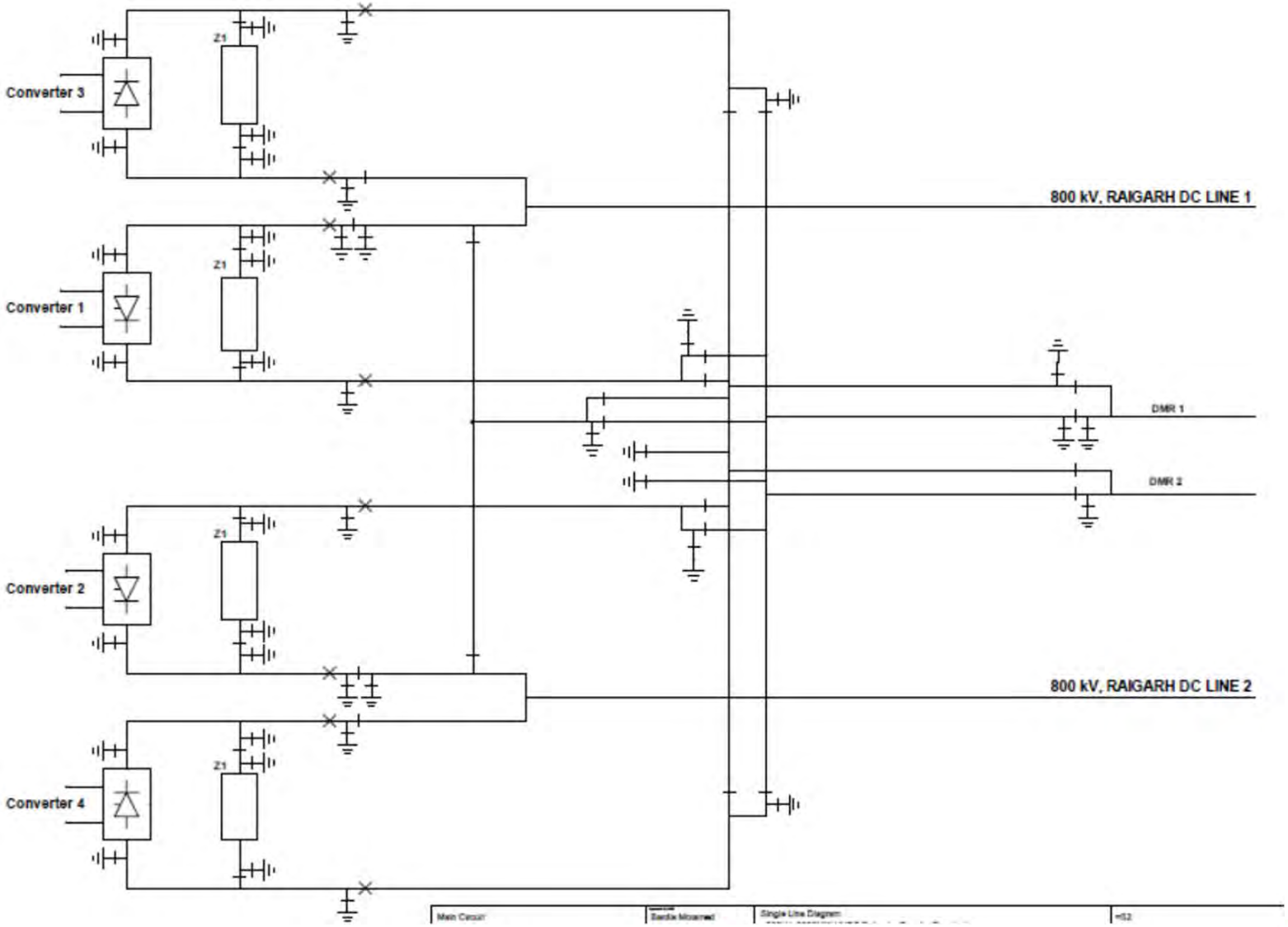
RP800
Raigarh GIS



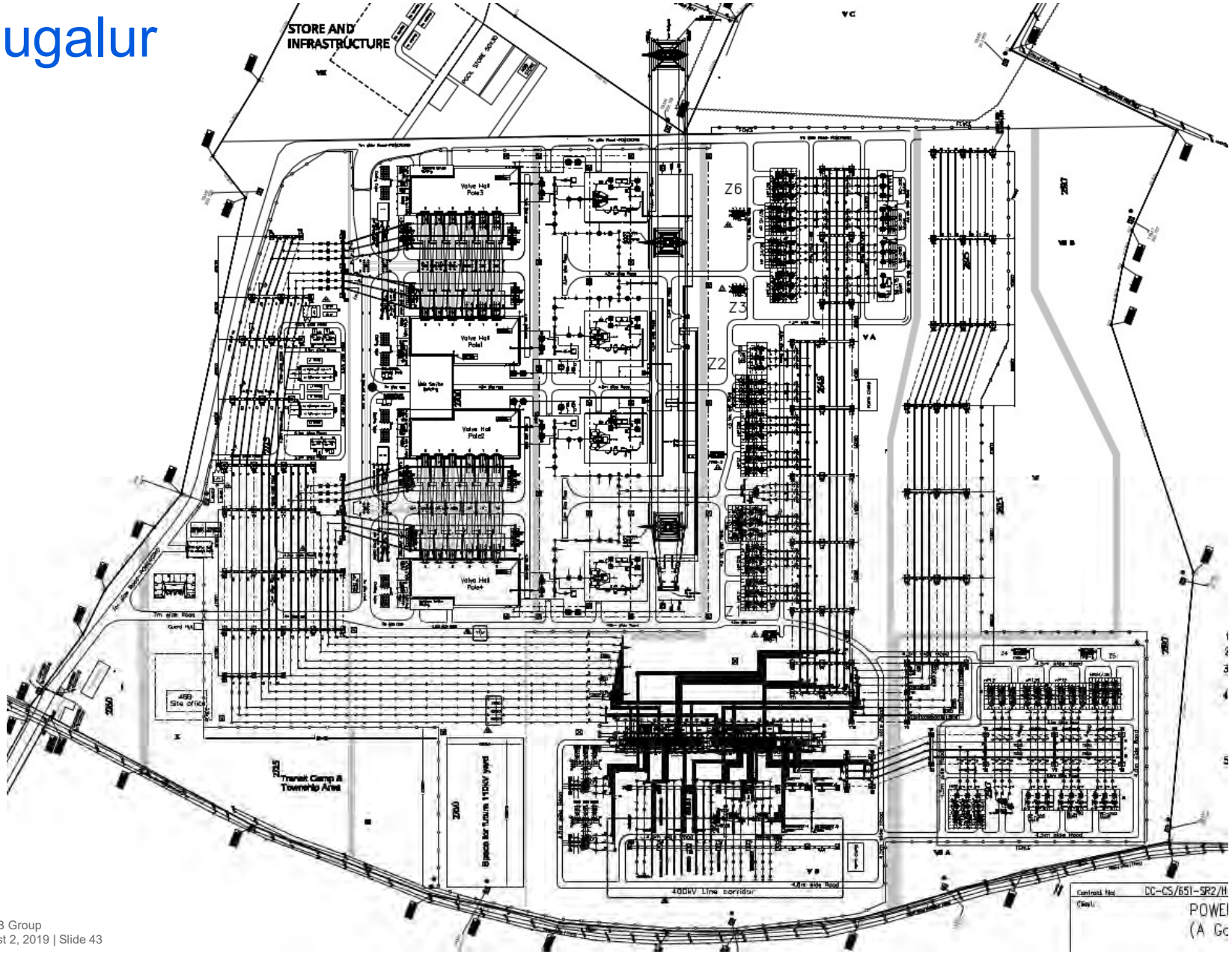
RP800
Pugalur



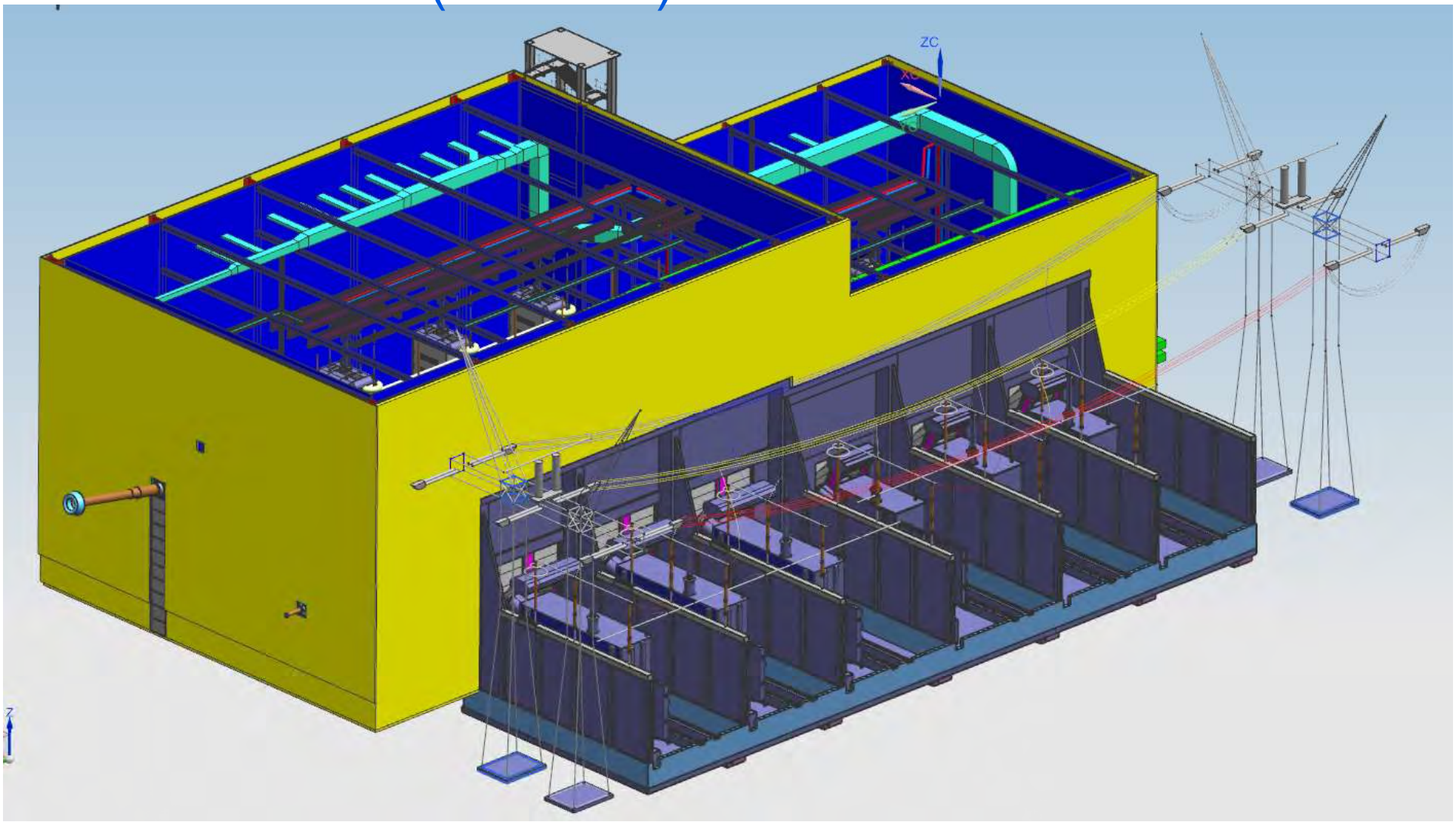
RP800
Pugalur



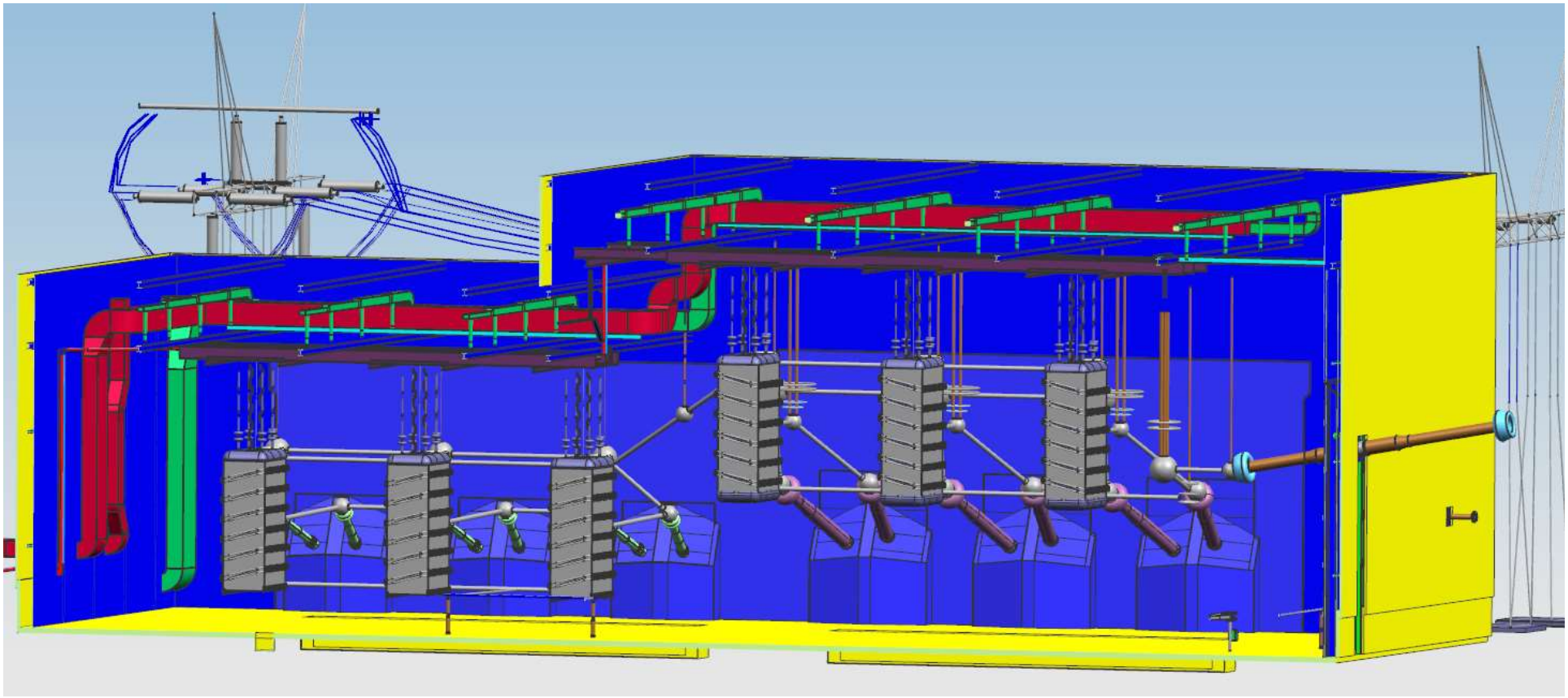
RP800
Pugalur



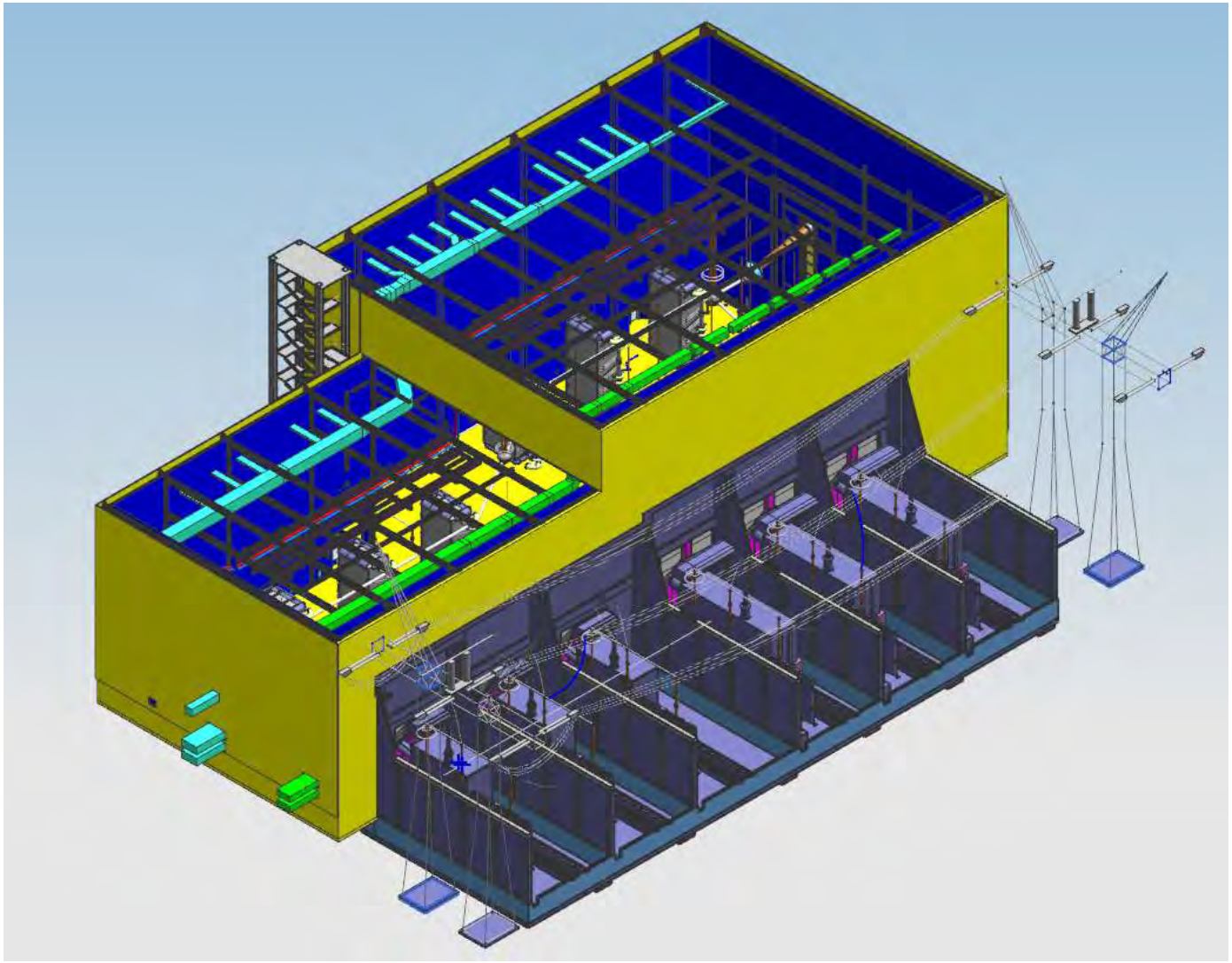
RP800
Converter Area (Pole 1/4)



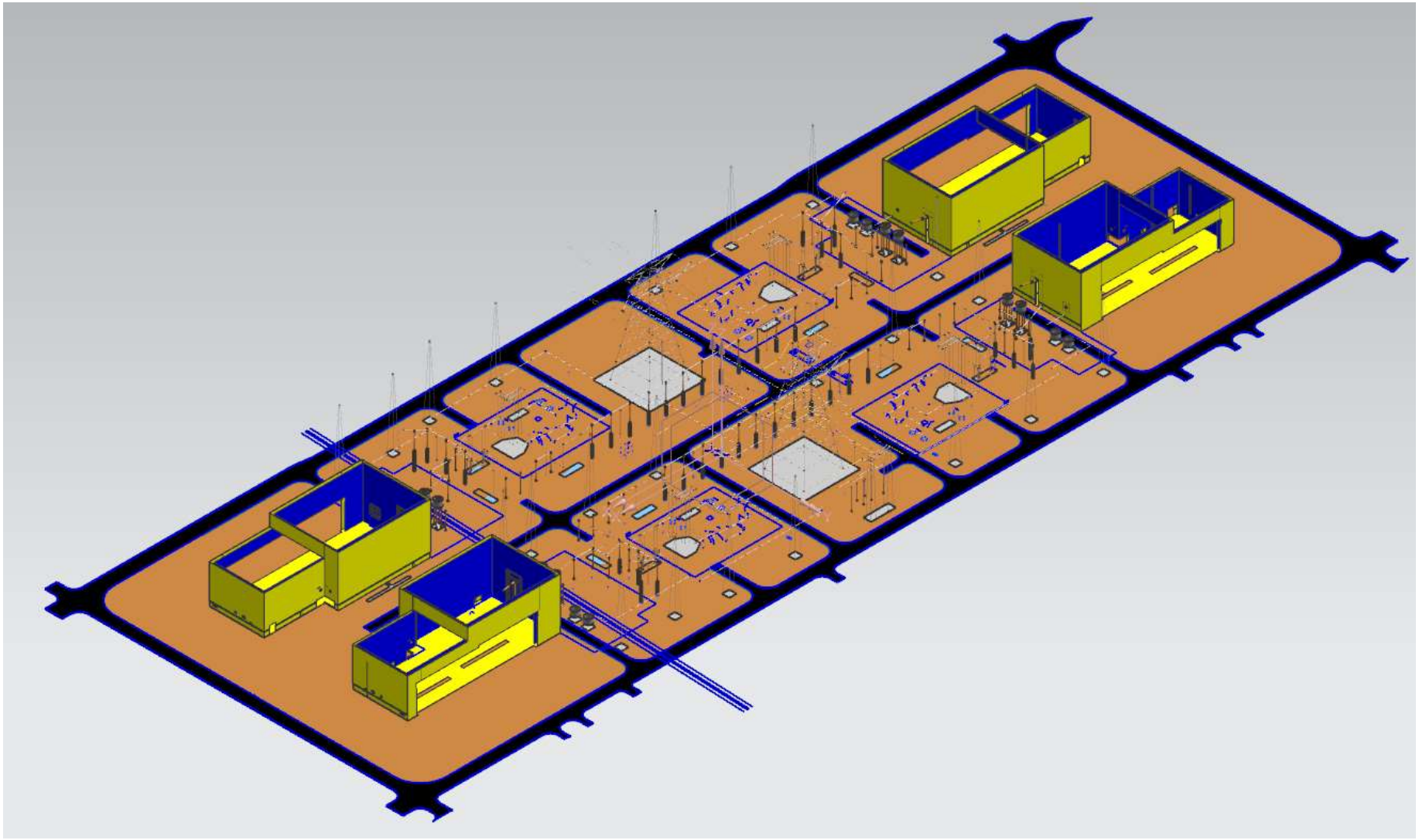
RP800
Valve Hall Area (Pole 1/4)



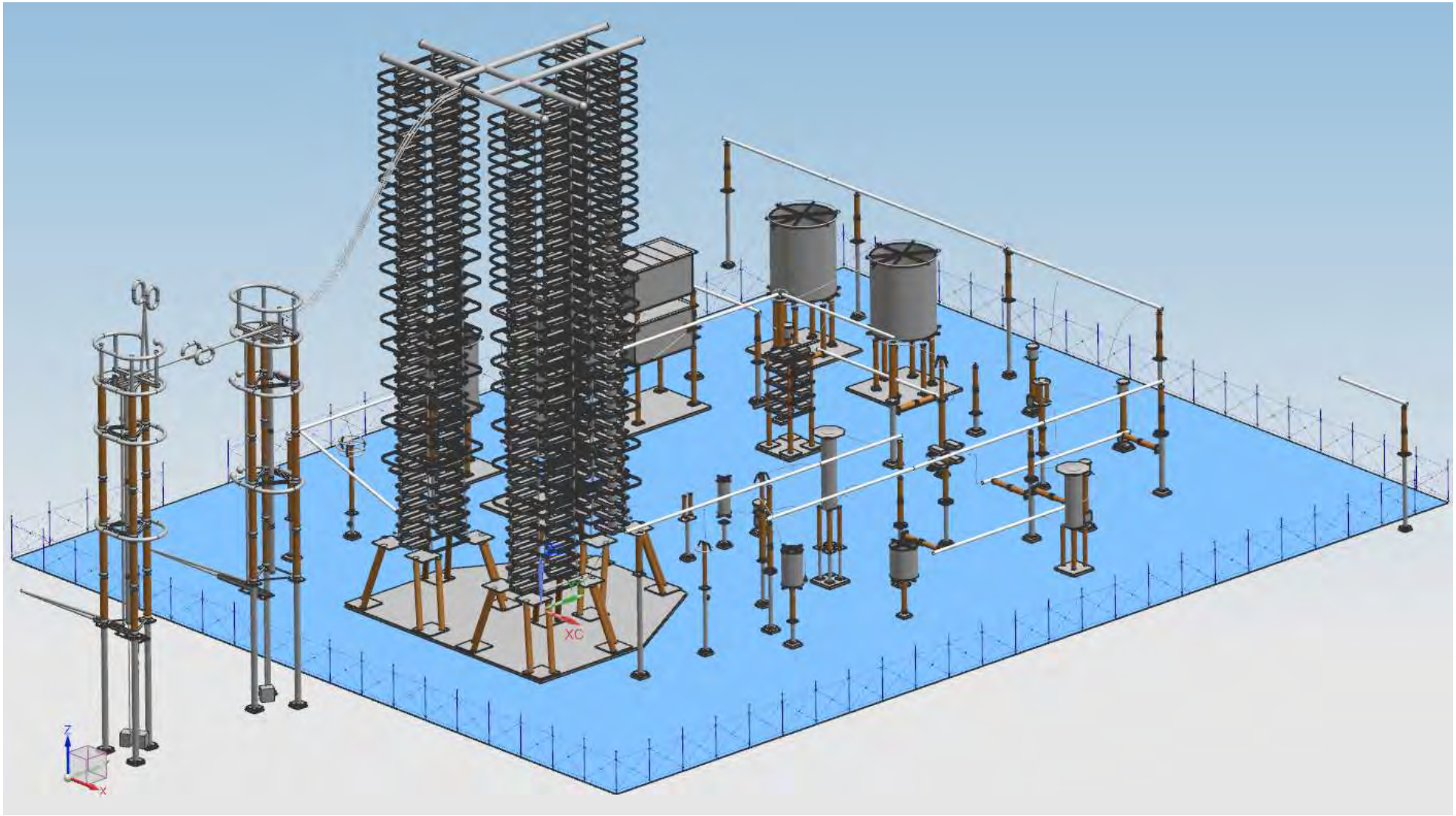
RP800
Valve Hall Area (Pole 2/3)



RP800 - Raigarh
Layout



RP800
DC Filter Area



RP800
DC Yard (Pole 1, Raigarh)