Central Electricity Authority
System Planning & Project Appraisal Division
Sewa Bhawan, R.K. Puram, New Delhi – 110066

No. 52/6/SP&PA-2015/ 1234-56 Date: 28-May-2015

Sub: **Joint Meeting** of the Standing Committee on Power System Planning of **Southern** Region and **Western** Region - **Minutes of the meeting**

Sir,

The **Joint Meeting** of the Standing Committee on Power System Planning of **Southern** Region and **Western** Region was held on 20 April, 2015 in NRPC Committee room, Katwaria Sarai, New Delhi.

The Minutes of the meeting are enclosed.

The Minutes are available at CEA's website (www.cea.nic.in).

Yours faithfully,

P Jindal
28/05/2015

(Pardeep Jindal)
Director (SP&PA)
(Telephone: 011 26732325, Fax No. 011 26102045)

To

Constituents of SR and WR SCPSP

1. The Member Secretary, Southern Regional Power Committee, 29, Race Course Cross Road, **Bangalore 560 009**. **FAX : 080-22259343**	2. The Member Secretary, Western Regional Power Committee, MIDC Area, Marol, Andheri East, Mumbai *Fax 022 28370193*

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3. CEO, POSOCO, B-9, Qutub Institutional Area, Katwaria Sarai, **New Delhi-110016**	4. COO (CTU, Planning), Power Grid Corp. of India Ltd. "Saudamini", Plot No.2, Sector-29, **Gurgaon 122 001, Haryana**. **FAX : 95124-2571932**

5.The Director (Transmission), Transmission Corp. of Andhra Pradesh Ltd., (APTRANSCO) Vidyut Soudha, **Hyderabad – 500 082.** **FAX : 040-66665137**	6. The Director (Grid Transmission and Management), Transmission Corp. of Telangana Ltd., (TSTRANSCO) Vidyut Soudha, Khairatabad **Hyderabad – 500 082.** **FAX : 040-23321751**
7 The Director (Transmission), Karnataka State Power Trans. Corp.Ltd., Cauvery Bhawan, **Bangalore - 560 009**. **FAX : 080 -22228367**	8. The Director (Trans. & System Op.), Kerala State Electricity Board, Vidyuthi Bhawanam, Pattom, **Thiruvananthapuram - 695 004.** **FAX : 0471-2444738**
9. Member (Distribution), Tamil Nadu electricity Board (TNEB), 6th Floor, Eastern Wing, 800 Anna Salai, **Chennai - 600002.** **FAX : 044-28516362**	10. The Superintending Engineer –I, First Floor, Electricity Department, Gingy Salai, Puducherry – 605 001. FAX : 0413-2334277/2331556

11. Director (Operation), MAHATRANSCO, 'Prakashgad', Plot No.G-9, Bandra-East, Mumbai-400051 **Fax 022-26390383/26595258**	12. The Chief Engineer, Electricity Department, The Government of Goa, Panaji ***Fax 0832 2222354***
13. Chairman and Managing Director, MPPTCL, Shakti Bhawan, Rampur, Jabalpur-482008 ***Fax 0761 2664141***	14. Executive Engineer (Projects) UT of Dadra & Nagar Haveli, Department of Electricity , Silvassa ***Ph. 0260-2642338/2230771***
15. The Managing Director, CSPTCL, Dangania, Raipur (CG)-492013 ***Fax 0771 2574246/ 4066566***	16. Executive Engineer Administration of Daman & Diu (U.T.) Department of Electricity Moti Daman-396220 ***Ph. 0260-2250889, 2254745***
17. The Managing Director, GETCO, Sardar Patel Vidyut Bhawan, Race Course, Baroda-390007 **Fax 0265-2338164**	

18. The Director (Power), Corporate Office, Block – I, Neyveli Lignite Corp. Ltd., **Neyveli , Tamil Nadu – 607 801.** **FAX : 04142-252650**	19. Director (Projects), National Thermal Power Corp. Ltd. NTPC Bhawan, Core-7, Scope Complex, Lodhi Road, **New Delhi-110003.** **FAX-011-24360912**
20. Director (Operations), NPCIL, 12th Floor, Vikram Sarabhai Bhawan, Anushakti Nagar, Mumbai – 400 094. FAX : 022- 25991258	

Copy to:

1.	The Director (Projects), Power Grid Corp. of India Ltd. "Saudamini", Plot No.2, Sector-29, **Gurgaon 122 001, Haryana**. **FAX : 95124-2571932**
2.	GM, SRLDC, 29, Race Course Cross Road, Bangalore 560 009 FAX – 080-22268725
3.	GM, WRLDC Plot no F-3, MIDC Area, Msarol, Andheri(East) Mumbai-400093 **Fax no 022-28235434**

Minutes for Joint Meeting of Standing Committee on Power System Planning in Southern Region and Western Region **held on 20 April, 2015 at NRPC, Katwaria Saria, New Delhi**

1. Introduction

1.1 Member(PS), CEA informed the participants that a ± 800 kV Raigarh (HVDC Stn, 6000 MW) – Pugalur (HVDC Stn,4000 MW) - Kerala (HVDC Stn,2000 MW) scheme was agreed in 37th meeting of SCPSPSR held on 31st July, 2014. He said that MoP has allocated this scheme to PGCIL for implementation under compressed time schedule. PGCIL vide their letter dated 13.01.2015 has proposed to modify the scope of the scheme. Since the issue involves both WR and SR, therefore a joint meeting of both the regions has been called.

1.2 CE(SP&PA) welcomed the participants and requested Director (SP&PA) to take up agenda item.

List of participants is given at Annex-I.

2.0 Modification proposed by PGCIL in Raigarh-Pugalur- Kerala 6000 MW HVDC System

2.1 Director (SP&PA), CEA informed that PGCIL vide their letter dated 13.01.2015 has proposed to **modify the scope** for the scheme "HVDC Bipole link between Western region (Raigarh, Chhattisgarh) and Southern region (Pugalur, Tamil Nadu)-Madakathara/ North Trichur (Kerala)", as given below:

(i) ± 800 kV Raigarh*(HVDC Stn) – Pugalur* (HVDC Stn) HVDC Bipole link with 6000 MW capacity and 6000 MW of HVDC terminal at Raigarh and Pugalur.

(ii) Establishment of VSC based 2000 MW HVDC link between Pugalur and North Trichur* (Kerala) with 2000 MW VSC based HVDC terminal at Pugalur and North Trichur each (The transmission link between Pugalur and Kerala shall be through HVDC OH lines going into Kerala territory and the portion of the link where ROW issues are anticipated shall be established through UG cable upto Trichur terminal).

(iii) LILO of North-Trichur – Cochin 400 kV (Quad) D/c line at North Trichur HVDC Stn.

(iv) Pugalur HVDC Station – Pugalur (Existing) 400kV (quad) D/c line.

(v) Pugalur HVDC Station – Arasur 400kV (quad) D/c line with 80 MVAR switchable line reactor at Arasur end.

(vi) Pugalur HVDC Station – Thiruvalam 400kV (quad) D/c line with 80 MVAR switchable line reactor at both ends.

(vii) Pugalur HVDC Station – Edayarpalayam 400kV (quad) D/c line with 63 MVAR switchable line reactor at Edayarpalayam end.

(viii) Edayarpalayam – Udumalpet 400kV (quad) D/c line.

(ix) Establishment of 400/220kV substation at Edayarpalayam with 2x500 MVA transformers and 2x125 MVAR bus reactors.

(Note: *400 kV AC switchyard at the HVDC terminals shall be with hybrid system of AIS & GIS)

2.2 He said that this scope is different from the earlier scope as agreed in the 37th meeting of the SCPSPSR, held on 31-July-2014. He elaborated the difference as given below:

SCPSPSR	MoP	PGCIL's New Proposal
(i) Raigarh(HVDC Stn) – Pugalur (HVDC Stn) ±800kV 6000 MW HVDC bipole.	(i) ± 800 kV Raigarh (HVDC Stn) – Pugalur (HVDC Stn) – Madakkathara (HVDC Stn) HVDC Bipole line.	(i) ± 800 kV Raigarh (HVDC Stn) – Pugalur (HVDC Stn) HVDC Bipole link with 6000 MW capacity. And 6000 MW of HVDC terminal at Raigarh and Pugalur.
(ii) Establishment of Raigarh HVDC Stn ±800kV with 6000 MW HVDC terminals	(ii) Establishment of Raigarh HVDC Stn with 6000 MW HVDC terminals	
(iii) Establishment of Pugalur HVDC Stn with 6000 MW HVDC terminals or Alternatively: (a) Pugalur HVDC Stn with 4000 MW terminal, and	(iii) (a)Establishment of Pugalur HVDC Stn with 4000 MW HVDC terminalsl,	

SCPSPSR	MoP	PGCIL's New Proposal
(b) Madakkathara, in Kerala HVDC Stn with 2000 MW terminal	and (b) Madakkathara, in Kerala HVDC Stn with 2000 MW terminal and inter-connection with existing 400kV AC S/S at Madakkathara.	(ii)Establishment of VSC based 2000 MW HVDC terminals at Pugalur and North Trichur (Kerala) each.
(Connectivity between Pugalur and Madakkathara/North Trichur as an extension of conventional HVDC line)	(Connectivity between Pugalur and Madakkathara/North Trichur as an extension of conventional HVDC line)	(iii)The transmission link between Pugalur and Kerala shall be through HVDC OH lines going into Kerala territory and the portion of the link where ROW issues are anticipated shall be established through UG cable upto Trichur terminal.
(iv) Inter-connection with existing 400kV AC S/S at Madakkathara	(iv) Inter-connection with existing 400kV AC S/S at Madakkathara	(iv)LILO of North-Trichur – Cochin 400 kV (Quad) D/c line at North Trichur HVDC Stn.
(AIS)	(AIS)	400 kV AC switchyard at the HVDC terminals shall be with hybrid system of AIS & GIS

3.0 Issues for discussion, involved in the change of scope:

3.1 In regard to PGCIL's new proposal, CEA had conveyed following observations to PGCIL:

(i) The new proposal consists of additional + 320 kV, 2000 MW inverter/ Converter terminals at Pugalur and North Trichur.

(ii) The above is in addition to ±800 KV 6000 MW inverter/ Converter terminals at Raigarh and Pugalur. Thus total 8000 MW terminal sets are proposed instead of 6000 MW.

(iii) The additional 2000 MW capacity terminal-set would be VSC based HVDC technology instead of conventional HVDC technology.

(iv) The reason of this modification in the scope, as given by PGCIL, is uncertainty/ delay in obtaining 69m RoW for the ±800 kV HVDC line between Pugalur and N Trichur. Therefore, the proposal also contains

constructing Pugalur- N Trichur link as cable or partly as combination cable/ Over -head.

(v) The now suggested modifications would have additional cost impact, primarily, due to following aspects:

a. Additional set of 2000 MW terminal

b. Use of VSC technology which is costlier then conventional HVDC by about 1.3-1.7 times.

c. Cost of VSC HVDC cable between Pugalur and N Trichur including cost required to purchase 5 m width of land throughout the stretch.

(vi) The certainty/ uncertainty in procurement of 5 m wide land in the stretch from North Trichur up to Kerala border to Pugalur, for cable laying also need to be deliberated.

(vii) Barring cost implications, the use of VSC technology for overhead transmission line is yet to be established/ matured and at present there are only one or two such overhead lines in the world.

(viii) Can the additional cost be utilized in setting up an ISTS generation plant in Kerala, which would be in addition to the agreed 2000 MW HVDC terminal in Kerala.

3.2 Considering above observations, PGCIL was requested to prepare a detail note covering following aspects. Accordingly, PGCIL has furnished a note on above observation vide their letter dated 15.03.2015 which is given at **Annex-II** for reference:

a. Alternative **feasible configurations** of Converter stations.

b. **The issues in RoW** (69 m for ±800 kV HVDC) in Pugalur – N.Trichur part of the HVDC line in Kerala / Tamil Nadu portions, if any.

c. **The issues in RoW** for the Raigarh- Pugalur portion of the HVDC line, in Chhatisgarh / Maharashtra / Telangana / Andhra Pradesh / Karnataka / Tamilnadu, if any.

d. Possibility of using RoW of the existing 220kV line from N. Trichur to Palaghat for the Pugalur - N. Trichur HVDC link. PGCIL may explore if it is possible to extend the existing RoW of this line of KSEB.

e. Cost of **DC cable (in Rs./km-route-length for the HVDC line)** including cost of **land procurement** (about 5m width for about 100km long stretch) for cable trenches in Kerala. (As these elements are first time in India, PGCIL may furnish basis of cost estimates including quotation from possible vendors.)

f. As this is a new technology, which are the possible vendors who can supply DC cable for 2000 MW +/- 320kV VSC based system.

g. **Comparative cost** of converter terminals for VSC based v/s conventional HVDC technologies. (As these elements are first time in India, PGCIL may furnish basis of cost estimates including quotation from possible vendors.)

h. As this is a new technology, which are the possible vendors who can supply terminal equipments for a 2000 MW +/- 320kV VSC based system.

i. **Comparative cost of two options considering capital cost(completed cost) of the scheme and including transmission** loss capitalization in two alternatives. It is understood that the VSC based terminals have higher transmission losses as compared to conventional technology.

j. **The amount of power (in MUs per annum)that is likely to be transmitted through this HVDC link.**

k. The number of Transition stations required and their cost.

l. Extra benefit/ Advantage/disadvantages/technological concerns of VSC technology and technical issues like DC fault for VSC based over-head lines.

m. **Any issues** if implemented in two stages/ or single contract but with staggered delivery.

n. **System Studies for** inter connection of North Trichur HVDC Station with 400kV system in Kerala. Indicative transmission system strengthening required in Kerala state network, so that 2000 MW gets absorbed in the Kerala without overloading/congestion of the 220kV or 110kV network in Kerala. It is requested that corresponding loadflow and SLD file may also be sent to CEA.

o. Fault levels at Pugalur HVDC station under various operating conditions for 2018-19 scenario for 16000 MW import in SR, i.e. with 6000 MW, 4000 MW, 2000 MW and 0 MW flow through this HVDC link. It is requested that corresponding loadflow /short-circuit file may also be sent to CEA.

4.0 Further deliberations in the meeting:

4.1 COO (CTU), PGCIL explained that out of the two possible alternatives. (i) **Alt-I** : providing parallel bipoles and operating as a multi terminal, 6000MW at Raigarh, 4000MW at Pugalur and 2000MW at North Trichur at ±800kV level and (ii) **Alt-II**: ±800kV 6000MW HVDC LCC from Raigarh to Pugalur and ±320kV 2000MW(2x1000MW) VSC HVDC from Pugalur to North Trichur. Alternative-II is being considered because of Right of way constraint. VSC technology is more suitable in case of ROW problems as cables can be used more easily and for ±800kV cable is not available. Also, with the VSC based terminals reactive support can be provided. This would improve the grid stability.

PGCIL informed that as per the survey carried out by them about 32 km of cable length in Kerala portion may be needed for Pugalur- Trichur link. They indicated that the total cost of the complete scheme from Raigarh up to Trichur would be about Rs. 20,000 crores. The presentation made by PGCIL in this regard is given at **Annex-IV.**

4.2 Member Secretary, WRPC said that the requirement of additional 2000 MW VSC based HVDC from Pugalur to Kerala is due to apparent RoW issues in Kerala. Director, CEA said that the possibility of using RoW of existing Palaghat – Trichur may be explored.

4.3 Kerala said that Row issue is expected between Palaghat and N. Trichur and if the line got stuck due to it, then the Raigarh- Pugalur link would remain under utilized. So, it is advisable to use the under ground cable instead of overhead line. He also said that for ±320 kV HVDC line about 35 m of RoW is needed which is similar to RoW for a 220kV D/C line. At some stretches of the proposed VSC HVDC overhead line the RoW of existing 220kV lines may be used. However, use of RoW of 220kV line for ± 800 kV HVDC which requires 69 m RoW may not be practically possible. He also said that the ±800k V

Terminal would require more space near N Trichur 400kV S/S and finding such space is difficult but for about ± 320kV HVDC terminal land requirement is about 30 acres only and can be made available.

4.4 Director (Projects), TANTRANSCO enquired about the possibility of building Pugaular- N. Trichur line as 400kV AC lines, instead of HVDC. COO (CTU), PGCIL replied that both Mysore- Kozhikode and Edamon- Cochin lines are stuck up because of severe RoW problem in Kerala. Therefore only possibility of the power supply to Kerala is through underground DC link wherever overhead line is not practically possible.

4.5 MS, SRPC emphasized the need for VSC based HVDC terminal at Pugalur and North Trichur each.

4.6 SE, MPPTCL (Madhya Pradesh) supported the new technology citing RoW as the main reason in Kerala, however, he raised his concern for the increased cost. PGCIL said that the cost of the complete scheme from Raigarh up to Trichur would be about 20,000 crores. Estimated cost of the projects, as provided by PGCIL, is given under Annexure-II of the Annex-II. MPPTCL said that the cost of such links should be borne by the beneficiary states and should not be a burden on other states.

4.7 SE, CSPTCL (Chhatisgarh) suggested to set up a new thermal power plant in Kerala, to cater to future load growth instead of such high investment in transmission system. There are number of land acquisition issues for setting up new pithead based generation capacity in coal rich states and RoW issues are also being faced for laying transmission lines required for evacuation of power from such pithead based generating stations. CEA stated that in the last five years no capacity has been added in Kerala and neither much is in construction where else the load of Kerala is going to increase by about 2000-3000 MW in next 5 years. So, practically, Kerala will have to import all its need from outside if they don't add generation capacity in their state. Director (Transmission), KSEBL informed that they are planning a thermal power plant in Kasargode but it will take some time to materialize.

4.8 Director (CEA), suggested that the whole system can be planned as 3 separate schemes., HVDC part, AC part and VSC part of the scheme can be treated as three schemes separately so that the work on all three of them can be started at the same time.

4.9 Director (WR), CEA asked whether Raigarh HVDC Station – Raigarh(Existing) 400kV (quad) 2xD/c lines would be sufficient for 6000 MW injection at Raigarh HVDC station.

4.10 CTU stated that there is a change in the scheme and now the Raigarh HVDC terminal would be adjacent to the existing AC substation only and would be an extended bus.

4.11 Director (Trans), KPTCL said that it is a new technology and he raised the issues of transport of such heavy cables on such stretches that have ROW issues in Kerala. He also expressed guide lines for use of EHV cable in transmission lines where there are RoW problems.

4.12 ED, PGCIL said that about 5 m width of land may have to be acquired through out the length of cable route. This requirement would be reduced to 2 to 4 m if the cable is laid along the highway. KSEB responded that they are exploring the possibility of laying the cable along the NH 47.

4.13 AGM (System Operation), POSOCO said that if we have to adopt a VSC option from Pugalur to Kerala, we may consider a different take off point other than Pugalur. This would give better flexibility and reliability in comparison to Pugalur having 8000 MW (6000 MW LCC + 2000 MW VSC) terminal at one place only. He also said that some of the presentations enclosed with the agenda suggest that each cable is generally capable of 200-250 MW; so do we need 8-10 cables for 2000 MW; does the 5 m ROW capture all this? CTU subsequently clarified that single cable is available for 1000 MW.

POSOCO also expressed that HVDC-HVDC controller interactions could be a concern due to close proximity of HVDC terminals, and required studies. COO(CTU), PGCIL stated that for VSC systems, HVDC-HVDC controller interactions may arise which would be analyzed at the time of detail designing.

POSOCO also said that the STATCOMs earlier planned at Trichy and Udumulpeta may need to be reviewed in the light of VSC terminal at Pugalur considering the dual advantages of VSC based HVDC systems. PGCIL explained that the review of STATCOM would not be needed because the natural STATCOM of VSC link will be for HVDC only.

POSOCO also stated that the behavior of HVDC system as well as the power system stability needs to be studied in the planning horizon considering eventuality such as delayed clearance of faults in the AC transmission system

in close proximity to HVDC terminals (Kolar, Pugalur, Champa etc), disconnection of large wind farms in Tamilnadu in the absence of Fault Ride Through (FRT) capability etc.

4.14 Director(SP&PA), CEA said that presently there is only one overhead link built using VSC HVDC technology (which is presently under construction) having capacity of the order of 1000 MW or more in the world. PGCIL said that in the present technology, there is a minor issue on fault clearing time for overhead VSC links. The link would be out for about 1- 2 second under transient fault, after which it is restored.

4.15 Director(SP&PA), CEA said that additional 220 kV outlets which would be commissioned by KSEBL for evacuation of 2000 MW must also be listed out, otherwise as per system studies, only 610 MW, out of 2000 MW of power could be transmitted. The preliminary studies in this regard were presented which are enclosed at **Annex-III.**

4.16 CEA informed that Gujarat Electricity Transmission Co.(GETCO), vide their email dated 16-04-2015 has conveyed their no objection to the proposed system (copy enclosed at **Annex-V).**

4.17 The overload capacity of the HVDC system in case of contingency was also discussed. Director(SP&PA), CEA stated that provision of an overload capacity for contingency is only for short duration, and keeping an overload capacity on continuous basis would tantamount to under-stating of the equipment ratings. Therefore, after discussion it was agreed that this HVDC system would be designed with normal overload ratings i.e. 20% overload for 30 minutes and 10% overload for 2 hours.

5.0 After further deliberation following systems were agreed:

5.1 <u>Scheme # 1:</u> Raigarh-Pugalur 6000 MW HVDC System

1. Establishment of Raigarh HVDC Station <u>+</u>800kV with 6000 MW HVDC terminals. This Raigarh Station would be implemented with extended bus of Raigarh(Kotra) existing 400kV S/S. The HVDC Station would have GIS for 400kV part and AIS for HVDC part.

2. Establishment of Pugalur HVDC Stn ±800kV with 6000 MW HVDC terminals. The HVDC Station would have GIS for 400kV part and AIS for HVDC part.
3. ± 800 kV Raigarh (HVDC Stn) – Pugalur (HVDC Stn) HVDC Bipole link with 6000 MW capacity.

This system would be designed with normal 20% overload for 30 minutes and 10% overload for 2 hours, as discussed above.

Estimated cost of this scheme is Rs. 13776 crore

5.2 Scheme # 2: AC System strengthening at Pugalur end

1. Pugalur HVDC Station – Pugalur (Existing) 400kV (quad) D/c line
2. Pugalur HVDC Station – Arasur 400kV (quad) D/c line.
3. Pugalur HVDC Station – Thiruvalam 400kV (quad) D/c line with 2x80 MVAR line reactor at Pugalur HVDC Station end and 2x63 MVAR line reactor at Thiruvalam 400kV end.
3. Pugalur HVDC Station – Edayarpalayam 400kV (quad) D/c line with 63 MVAR switchable line reactor at Edayarpalayam end.
4. Edayarpalayam – Udumulpeta 400kV (quad) D/c line.

   (Establishment of 400/220kV substation at Edayarpalayam with 2x500 MVA transformers and 2x125 MVAR bus reactors would be under the scope of TANTRANSCO. The bay for ISTS transmission lines at Edayarpalayam would be implemented as ISTS.)

Estimated cost of this scheme is Rs. 2008 crore

5.3 Scheme # 3: Pugalur- Trichur 2000 MW VSC Based HVDC System

1. ±320kV, 2000 MW VSC based HVDC terminal at Pugalur. The HVDC Station would have GIS for 400kV part and AIS for HVDC part.
2. ±320kV, 2000 MW VSC based HVDC terminal at North Trichur. The HVDC Station would have GIS for 400kV part and AIS for HVDC part.
3. Establishment of VSC based 2000 MW HVDC link between Pugalur and North Trichur* (Kerala).

(*part/parts of this link, in the Kerala portion, may be implemented as underground cable where implementation as overhead transmission line is difficult because of RoW issues).

4. LILO of North-Trichur – Cochin 400 kV (Quad) D/c line at North Trichur HVDC Stn.

Estimated cost of this scheme is Rs. 3769 crore

5.4 Additional system strengthening to be identified by KSEBL, jointly with CEA and CTU, for enabling Kerala to absorb up to 2000 MW of power received through this 2000 MW HVDC link. This system strengthening would be implemented by KSEBL as intrastate transmission system in Kerala.

5.5 The above schemes may be implemented as separate schemes however it is important that the scheme no. 2 and Scheme no. 3 should be in place before commissioning of 6000 MW Raigarh- Pugalur link.

Annex-I

List of participants for the Joint Standing Committee on Power System Planning in Southern Region and Western Region held on 20-04-2015 at NRPC Office, Katwaria Sarai, New Delhi

Sl. No.	Name and Organization	Designation
	Central Electricity Authority (CEA)	
1.	Major Singh	Chairperson (I/c) and Member (PS)
2.	K K Arya	Chief Engineer(SP&PA)
3.	Pardeep Jindal	Director (SP&PA)
4.	Awdesh K. Yadav	Director (SP&PA)
5.	Manjari Chaturvedi	Deputy Director (SP&PA)
6.	Shivani Sharma	Deputy Director (SP&PA)
	Southern Region Power Committee (SRPC)	
1.	S.R.Bhat	Member Secretary
2.	Anil Thomas	EE
	Western Region Power Committee(WRPC)	
1.	S. D. Taksande	Member Secretary
	Power Grid Corporation of India Ltd (PGCIL)	
1.	I. S.Jha	Dir(Proj.)
2.	Seema Gupta	COO-CTU
3.	R. K. Chauhan	ED
4.	Mukesh Khanna	AGM(CTU Plg.)
5.	B. B. Mukherjee	DGM
6.	V.Thayagrajan	Asstt GM
7.	Ankita Singh	Sr. Engineer(CTU Plg.)
	Power System Operation Corp. Ltd (POSOCO)	
1.	S. R. Narasimhan	AGM(SytemOp) (NLDC)
2.	N. Nallarasan	DGM(NLDC)
3.	Anbunesan. G	AGM(SRLDC)
4.	S.P. Kumar	DGM(SRLDC)

Sl. No.	**Name and Organization**	**Designation**
5.	Madhukar G	Dy. Manager (SRLDC)
6.	P. Mukhopadhyay	GM(WRLDC)
7.	Vivek Pandey	CE (WRLDC)
8.	Abhimanyu Gartia	DGM(WRLDC)
	Chhattisgarh State Power Transmission Co Ltd(CSPTCL)	
1.	D.K. Chanda	SE
	Madhya Pradesh Power Trans. Corp. Ltd. (MPPTCL)	
1.	M.M. Dhoke	SE
2.	R.S. Shrivuli	ACE
	Kerala State Electricity Board Ltd(KSEBL)	
1.	K Venugopal	Director(T&SO)
	Tamil Nadu Electricity Board/TANGEDCO/ TANTRANSCO	
1.	R. Kaliselvan	Dir/Trans.
2.	S. Ramchadran	SE
	Karnataka Power Transmission Co Ltd(KPTCL)	
1.	Sumanth	Dir (Trans.)

Annex II

Point Wise Reply to Clarifications sought by CEA

(a): Alternative feasible configurations of Converter stations.

Reply - There are two possible alternatives. (i) **Alt-I** : providing parallel bipoles and operating as a multi terminal, 6000MW at Raigarh, 4000MW at Pugalur and 2000MW at North Trichur at ±800kV level and (ii) **Alt-II**: ±800kV 6000MW HVDC LCC from Raigarh to Pugalur and ±320kV 2000MW(2x1000MW) VSC HVDC from Pugalur to North Trichur.Here it may be mentioned that another alternative would be to consider conventional LCC HVDC from Pugalur to North Trichur. However Alternative-II is being considered because of Right of way constraint. VSC technology is more suitable in case of ROW problems as cables can be used more easily.

(b): The issues in RoW(69 m for ±800 kV HVDC) in Pugalur – N.Trichur part of the HVDC line in Kerala / Tamil Nadu portions, if any.

Reply- RoW problem is anticipated from Tamil Nadu -Kerala border to North Trichur primarily due to high value plantations.

(c): The issues in RoW for the Raigarh- Pugalur portion of the HVDC line, in Chhtisgarh / Maharashtra / Telangana / Andhra Pradesh / Karnatak/ Taminadu, if any.

Reply- As of now, normalRoW issues are foreseen in this portion.

(d): Possibility of using RoW of the existing 220kV line from N.Trichur to Palaghat for the Pugaur-N.Trichur HVDC link. PGCIL may explore if it is possible to extend the existing RoW of this line of KSEB.

Reply- The available RoW for 220kV line is 35 meters. The required RoW for composite 800 kV DC + 220 kV AC multi-circuit line is 69 meters. Preliminary survey has indicated that 50% of route is covered by rubber plantation. It may be difficult to obtain the additional RoW. Further, new type of tower is required with a height of 90 meters with wider foot print (approx. 35 mX35 m) against the (20mX20 m) of standard 800kV DC Tower and 8mx8m of 220kV D/c tower.

(e): Cost of DC cable (in Rs./km-route-length for the HVDC line) including cost of land procurement (about 5m width for about 100km long stretch) for cable trenches in

Kerala. (As these elements are first time in India, PGCIL may furnish basis of cost estimates including quotation from possible vendors.)

Reply- Approx. cost is 90Million Euro for 64km Route length. taking 1 euro=70 INR, cost work out to about INR 9.8 crore/km route length (source: public domain website from INELFE VSC Project, cable supplier- M/s Prysmian). Actual cost shall be known after tender/ Bidding.The cable route is yet to be finalized. There is a feasibility of taking the cable along National highways(NH47). In this case, the land procurement cost will be minimized.

(f): As this is a new technology, which are the possible vendors who can supply DC cable for 2000 MW +/- 320kV VSC based system.

Reply- Cable Supplierswho can supply the cable are (i)Prysmian, ii) ABB, iii) Nexan. The VSC technology using cable is well established and all renowned vendors have supplied no. of VSC projects world wide (copy enclosed at **Annexure-I**).

(g): Comparative cost of converter terminals for VSC based v/s conventional HVDC technologies. (As these elements are first time in India, PGCIL may furnish basis of cost estimates including quotation from possible vendors.)

Reply- Comparative cost of proposed Alternative-I & II is enclosed at **Annexure-II**.Budgetary quotation of major vendors is also enclosed at **Annexure-IIA**.

(h): As this is a new technology, which are the possible vendors who can supply terminal equipment for a 2000 MW +/- 320kV VSC based system.

Reply- The technology is very much proven and has been used worldwide as given in the Annexure-I. ABB, Siemens, Alstom have implemented various VSC project as indicated in the **Annexure-I**.

(i) Comparative cost of two options considering capital cost(completed cost) of the scheme and including transmission loss capitalization in two alternatives. It is understood that the VSC based terminals have higher losses as compared to conventional technology.

Reply- Terminal losses are generally of the order of 0.75 % of rated capacity at each terminal in case of LCC HVDC and 1.0 % of rated capacity at each terminal in case of VSC HVDC terminal. Line losses are current dependent. In case of Alt I Line loss is lower than Alt II . The transmission loss capitalization cost shall be approx. 195

Cr for VSC link considering overhead line. Introduction of DC cable will further reduce capitalization cost.

(j) The amount of power (in MUs per annum) that is likely to be transmitted through this HVDC link

Reply- Transmission system is planned based on peak power requirement and never based on energy. As indicated by KSEB during 37th SCM meeting, Kerala requires an additional import capability of around 2000 MW by year 2018 and 4000 MW by year 2022. The system requirement was discussed and a 2000MW HVDC to Pugalur was agreed.

Regarding energy transfer through the HVDC, making a conservative estimate power flow through the HVDC would be proportional to load,i.e the utilisation would be same as the load factor. The load factor of Kerala is 55% as per 18th EPS. Hence energy transfer works out to 9636MU (2000MW*365*24*55%). Here it may be mentioned that for the year 2013-14 as per the EPS energy demand of Kerala is 18400MU while the energy demand actually was 21577MU. As per EPS the energy demand would grow by about 5.8%. Hence projecting present demand, the energy demand would grow by more than 1500MU/ year beyond 2018-19. Hence the HVDC is expected to be utilised gainfully as envisaged during planning and less than 10% change in cost is not going to change the viability of the project.

(k) The number of Transition stations required and their cost.

Reply-Presently 01(one) no. envisaged. Cost per transition station is approx. 1 million USD.

(l): Extra benefit/ Advantage/disadvantages/technological concerns of VSC technology and technical issues like DC fault for VSC based over-head lines.

Reply- VSC offers significant merits in comparison of LCC scheme. Some of them are as follows:

- Independent active and reactive power support; Can be used as STATCOM
- Black start capability
- No commutation failure
- Use of conventional auto transformer in place of converter transformer
- Generally no or very little Harmonic filters requirements
- Less equipment
- Less space requirement due to less equipment

Some of the disadvantages are increased station losses (defined above in reply (i)), Slightly higher cost (10-15 % higher than that of LCC) and DC OH line fault

performance i.e. Slightly Higher recovery time e. g 750 mSec (considering 3 restart) for LCC and around 1000 msec for VSC.

(m): Any issues if implemented in two stages/ or single contract but with staggered delivery.

Reply- Even if a project is Staggered at the time of the contract itself, the staging and time period has to be indicated. If there is any uncertainty in time period of materialisation, then the same would lead to loading in the early stages itself. Further the project would have to be awarded to the same contractor itself to avoid contractual, and interface issues.

(n): System Studies for inter connection of North Trichur HVDC Station with 400kV system in Kerala. Indicative transmission system strengthening required in Kerala state network, so that 2000 MW gets absorbed in the Kerala without overloading/congestion of the 220kV or 110kV network in Kerala. It is requested that corresponding load flow and SLD file may also be sent to CEA.

Reply- Studies has been carried out with 2000MW injection at North Trichur. Injection is through LILO of Cochin-North Trichur 4000kV D/c (Quad line). The total load of Kerala is about 5425MW which is met by self-generation of 1360MW and import of 4065MW. The details of tie line flows are shown in Exhibit-I. From the Exhibit-I it is seen that Edamon-Tirunellveli is loaded to 363MW per circuit. Under one pole outage the loading on the line increases to 376MW on each circuit. For above load-generation balance in the absence of proposed HVDC bipole, loading on Edamon-Tirunellveli is 390MW per circuit.

Load flow simulations are plotted in **Exhibit-II & III**. Under (n-1) condition, no constraint is envisaged on line loadings around North Trichur. However, transformers at Cochin and North Trichur gets loaded to 694MW (630MW) and 780MW (630MVA) even under base case. Transformers augmentation as proposed during 37th SCM needs to be taken up with matching 220kV augmentation. Under (n-1-1) contingency if both North Trichur-North Trichur (HVDC) are taken under outage then the entire power would flow towards Kochin and about 1285MW is dropped through transformers and remaining power flows towards Trirunelvelli. Strengthening of 220kV to be taken up at Kochin.

Fault levels at Pugalur HVDC station under various operating conditions for 2018-19 scenario for 16000 MW import in SR, i.e. with 6000 MW, 4000 MW, 2000 MW and 0 MW flow through this HVDC link. It is requested that corresponding load flow /short-circuit file may also be sent to CEA.

Reply – Fault level at Pugalur HVDC with various HVDC flow levels are enclosed at **Exhibit-IV.** The results are tabulated below:

	HVDC Power flow	**Short Circuit level at Pugalur**
1	**0 MW**	**30.23 kA**
2	**2000MW**	**30.10 kA**
3	**4000MW**	**29.95 kA**
4	**6000MW**	**29.85 kA**

Annexure-II

Alternative-I: Raigarh-Pugalur-N.Trichur (6000MW+4000 MW+2000MW)

S.No.	Transmission Scheme	Est. Line Length (Km)	Estd. Cost in Rs(Crs.)
1	(+/-) 800 kV Raigarh (HVDC Stn) – Pugalur (HVDC Stn)-North Trichur (HVDC Stn)- HVDC Bipole line	2090	8151
2	Establishment of Raigarh HVDC Stn with 6000 MW HVDC terminals,Pugalur HVDC Stn with 4000 MW terminal and HVDC Stn with 2000 MW terminal North Trichur, in Kerala		8160
3	LILO of North-Trichur – Cochin 400 kV (Quad) D/c line at North Trichur HVDC Stn	100	264.8
4	Pugalur HVDC Station – Pugalur (Existing) 400kV (quad) D/c line	10	49.7
5	Pugalur HVDC Station – Arasur 400kV (quad) D/c line with 80 MVAR switchable line reactor at Arasur end	150	421.62
6	Pugalur HVDC Station – Thiruvalam 400kV (quad) D/c line with 80 MVAR switchable line reactor at both ends	330	863.34
7	Pugalur HVDC Station – Edayarpalayam 400kV (quad) D/c line with 63 MVAR switchable line reactor at Edayarpalayam end	160	444
8	Edayarpalayam – Udumalpet 400kV (quad) D/c line	85	228.95
9	Establishment of 400/220kV substation at Edayarpalayam with 2x500 MVA transformers and 2x125 MVAR bus reactors		62.56
10	Compensation Cost in Kerala Region	60	612
	Total Cost		**19257.97**

DELTA OF ALT I and ALT 2 | **653**

Alternative-II: Raigarh-Pugalur (6000MW) & Pugalur-N.Trichur(2000MW) VSC Link (40KM cable in Kerala)

S.No.	Transmission Scheme	Est. Line Length (Km)	Estd. Cost in Rs(Crs.)
1	± 800 kV Raigarh* (HVDC Stn) – Pugalur* (HVDC Stn) HVDC Bipole link with 6000 MW capacity	1840	7176
2	Establishment of HVDC Stn with 6000 MW HVDC terminals at Raigarh & Pugalur		6600
3	VSC Terminals at Pugalur & North Trichur		2730
4	(+/-) 320kV 2000 MW VSC based HVDC link between Pugalur and North Trichur (210Km OH +40Km UG)	250	774
5	LILO of North-Trichur – Cochin 400 kV (Quad) D/c line at North Trichur HVDC Stn.	100	264.8
6	Pugalur HVDC Station – Pugalur (Existing) 400kV (quad) D/c line.	10	49.7
7	Pugalur HVDC Station – Arasur 400kV (quad) D/c line with 80 MVAR switchable line reactor at Arasur end.	150	421.62
8	Pugalur HVDC Station – Thiruvalam 400kV (quad) D/c line with 80 MVAR switchable line reactor at both ends.	330	863.34
9	Pugalur HVDC Station – Edayarpalayam 400kV (quad) D/c line with 63 MVAR switchable line reactor at Edayarpalayam end.	160	444
10	Edayarpalayam – Udumalpet 400kV (quad) D/c line.	85	228.95
11	Establishment of 400/220kV substation at Edayarpalayam with 2x500 MVA transformers and 2x125 MVAR bus reactors.		62.56
12	Compensation Cost in Kerala Region	60	296
	Total Cost		**19910.97**

BUDGETARY QUOTATION OF +/-320kV, 2000 MW VSC TERMINALS AT PUGALUR & TRICHUR							
Sl. No.	Description	SIEMENS		ABB		ALSTOM	
		Million Euro	Equivalent M INR (1 Euro= 70 INR)	Million USD	Equivalent M INR (1 USD= 62INR)	Million Euro	Equivalent M INR (1 Euro= 70 INR)
1	±320kV, 2000 MW VSC TERMINALS AT PUGALUR & TRICHUR	390.00	27,300.00	520.00	32,240.00	558.00	39,060.00
2	Per MW cost	-	1.365 CR/ MW		1.6CR/ MW		1.9 CR/ MW

Annex- III

Sl.No	Case	Exhibit No.
1.	Base Case	Exhibit-1
2.	**Case-1:** N-1-1 of North Trichur-NTrichur HVDC 400 kV (Quad) D/c line	Exhibit-2
3.	N-1 of Palakkad-Udmulpet on Case-1	Exhibit-2a
4.	Kerala load met with permissible loading onKochinT/f on Case-1(3850MW Kerala load) & (600MW power flow on HVDC)	Exhibit-2b
5.	**Case-2:**HVDC to Kerala not considered and import through AC lines	Exhibit-3
6.	N-1 of Palakkad-Udumalpet on Case-2	Exhibit-3a
7.	Kerala load met with permissible loading under N-1 of Palakkad-Udumalpet (852MW)on Case-2(4670MW Kerala load)	Exhibit-3b
8.	**Case-3:** only 1000MW on Pugalur-NTrichur HVDC	Exhibit-4

In case-1 the 220kV network around Kochin area gets highly over loaded.
For Exhibit-2b power flow on HVDC is restricted to 600 MW and load of Kerala to 3850MW to bring the transformer loading on Cochin within the limits (610MW).

Exhibit - 1

SYSTEM STUDIES : Southern Region 2018-19

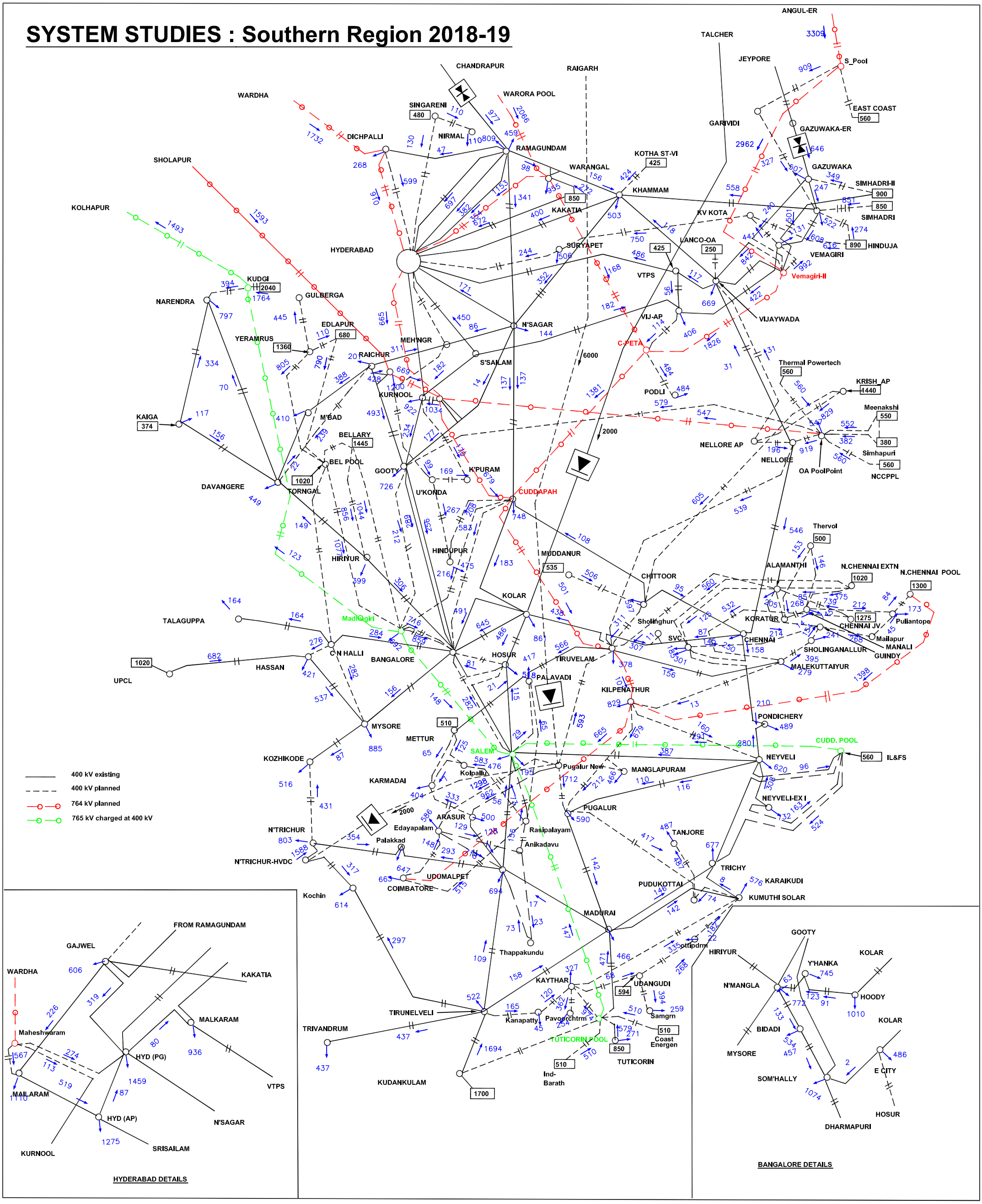


Exhibit - 2

SYSTEM STUDIES : Southern Region 2018-19

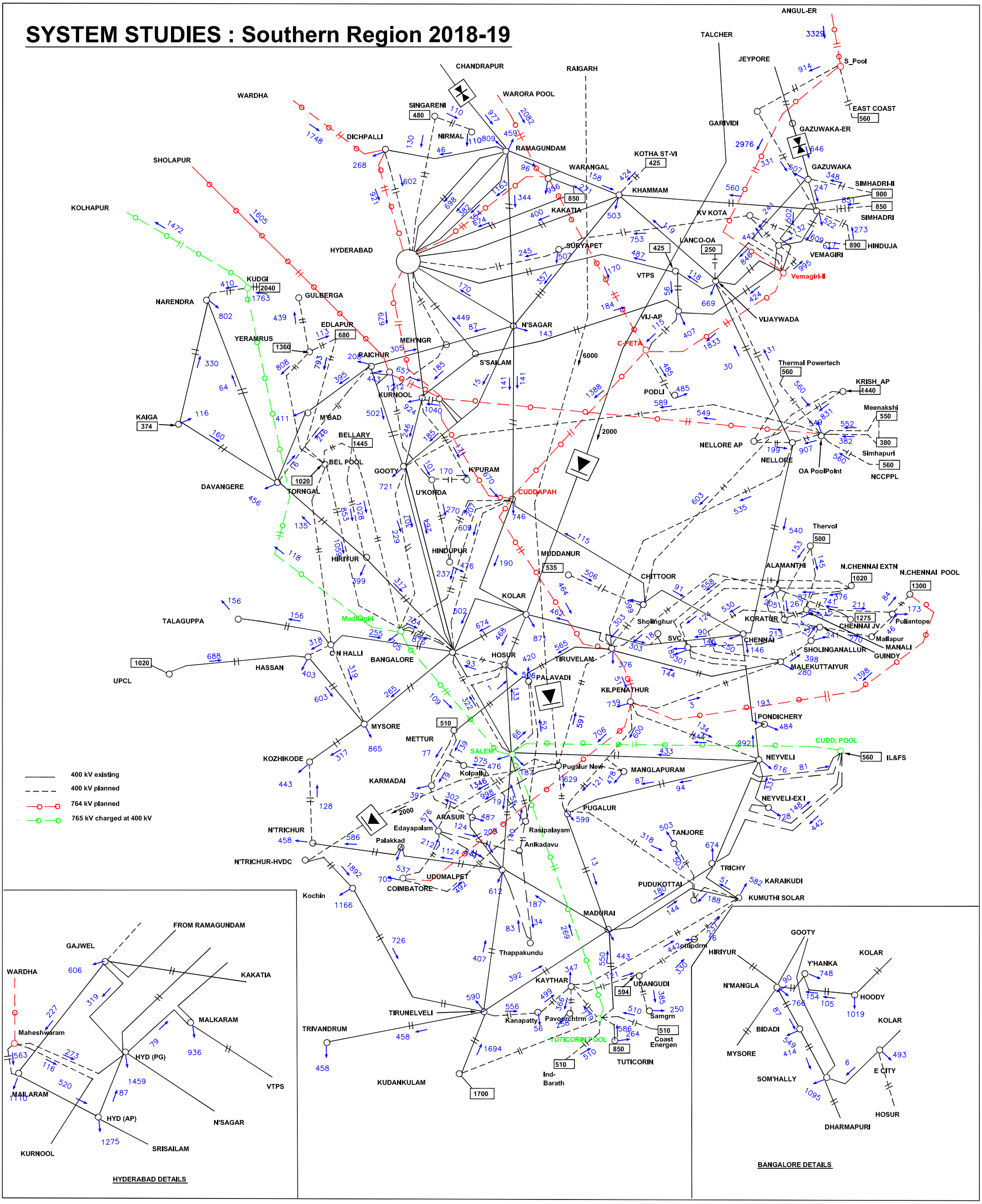


Exhibit - 2a

SYSTEM STUDIES : Southern Region 2018-19

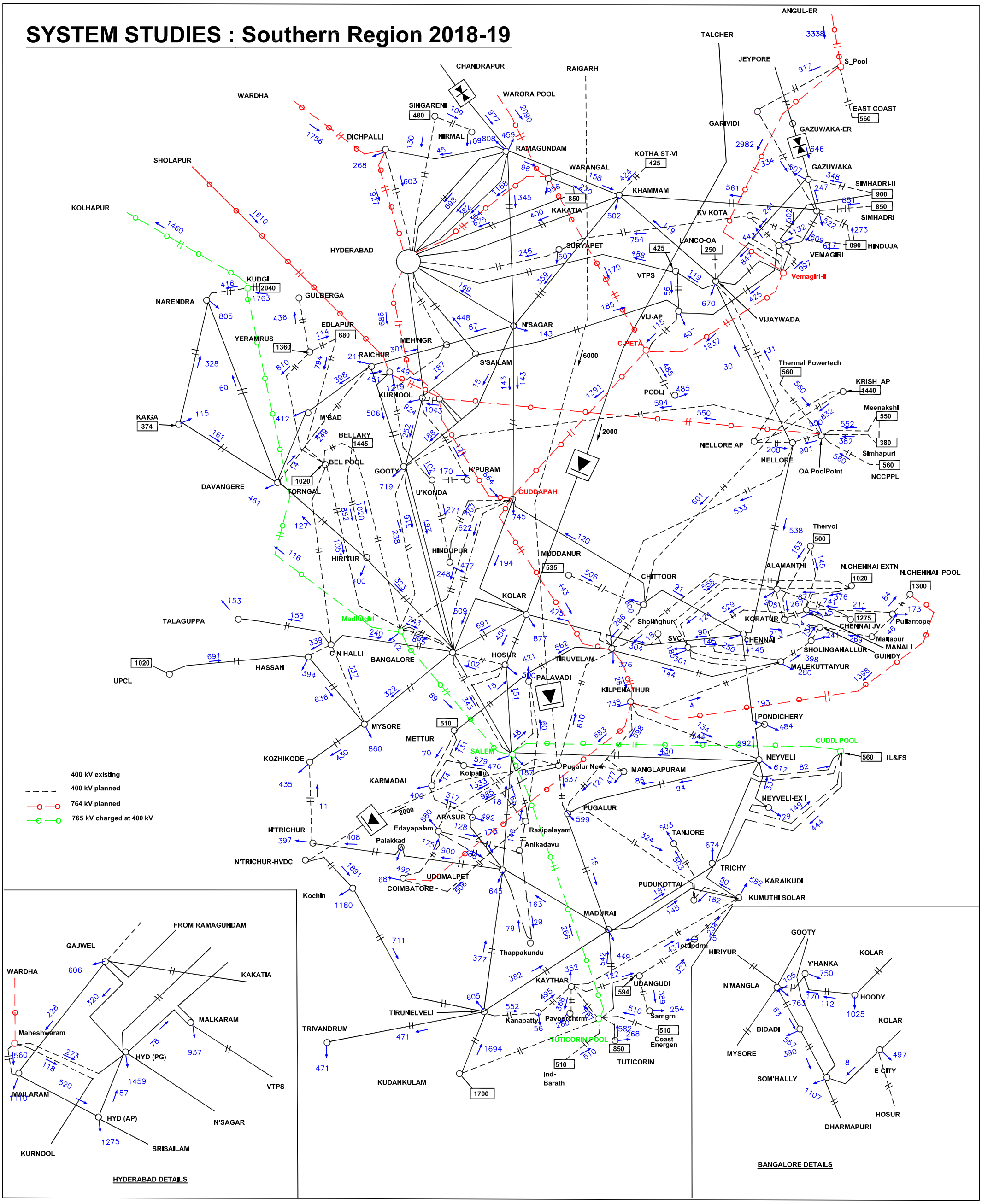


Exhibit - 2b

SYSTEM STUDIES : Southern Region 2018-19

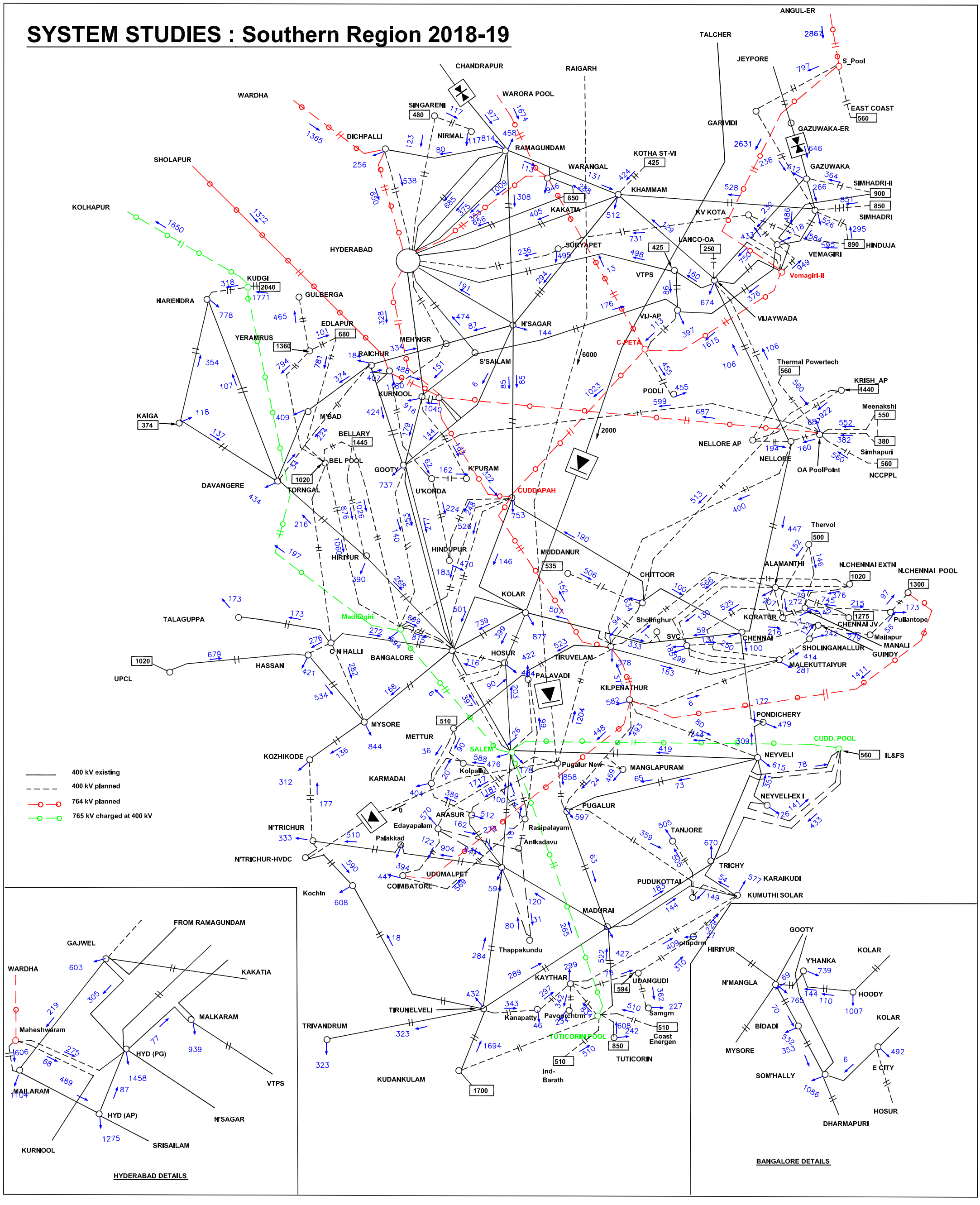


Exhibit - 3

SYSTEM STUDIES : Southern Region 2018-19

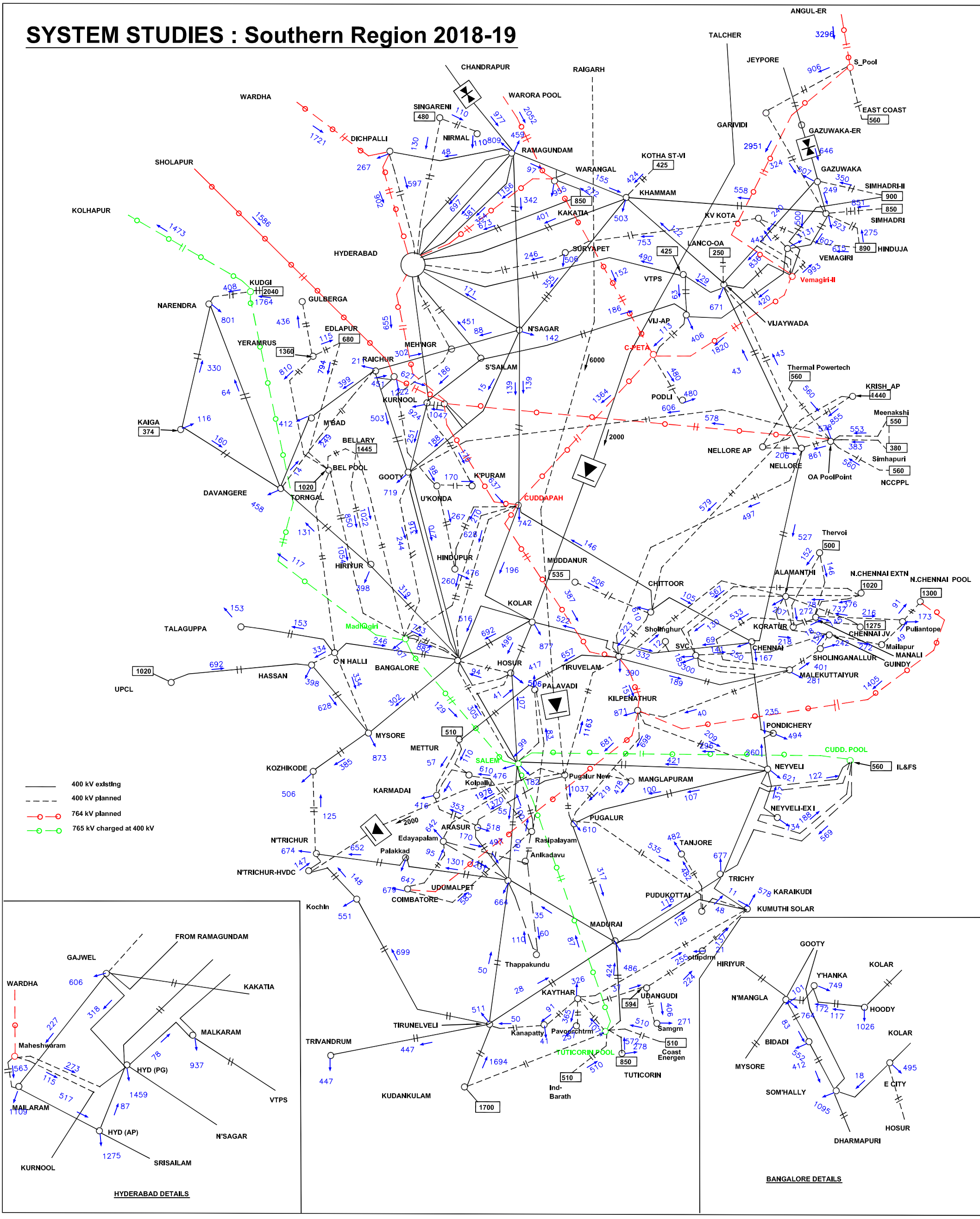


Exhibit - 3a

SYSTEM STUDIES : Southern Region 2018-19

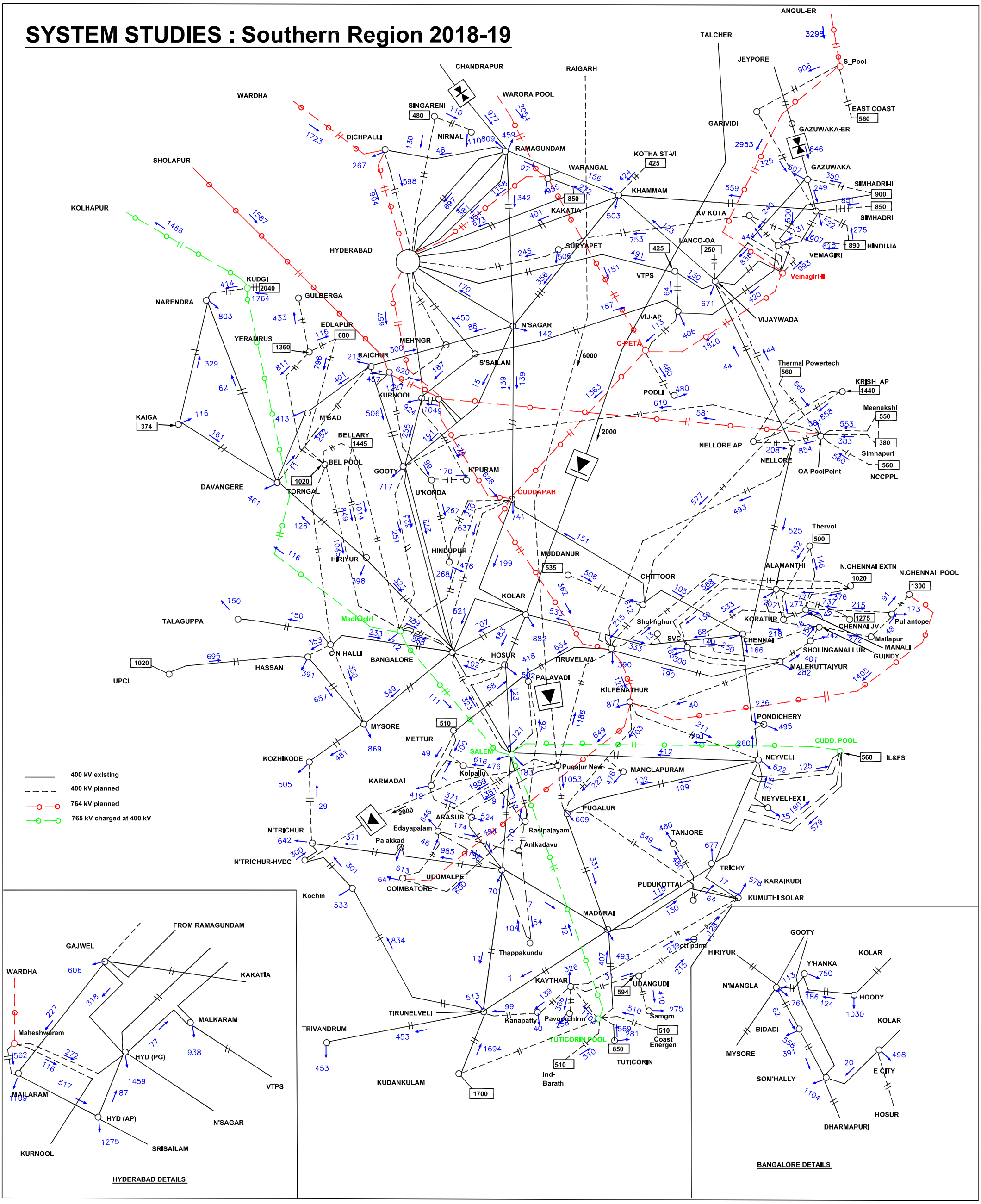


Exhibit - 3b

SYSTEM STUDIES : Southern Region 2018-19

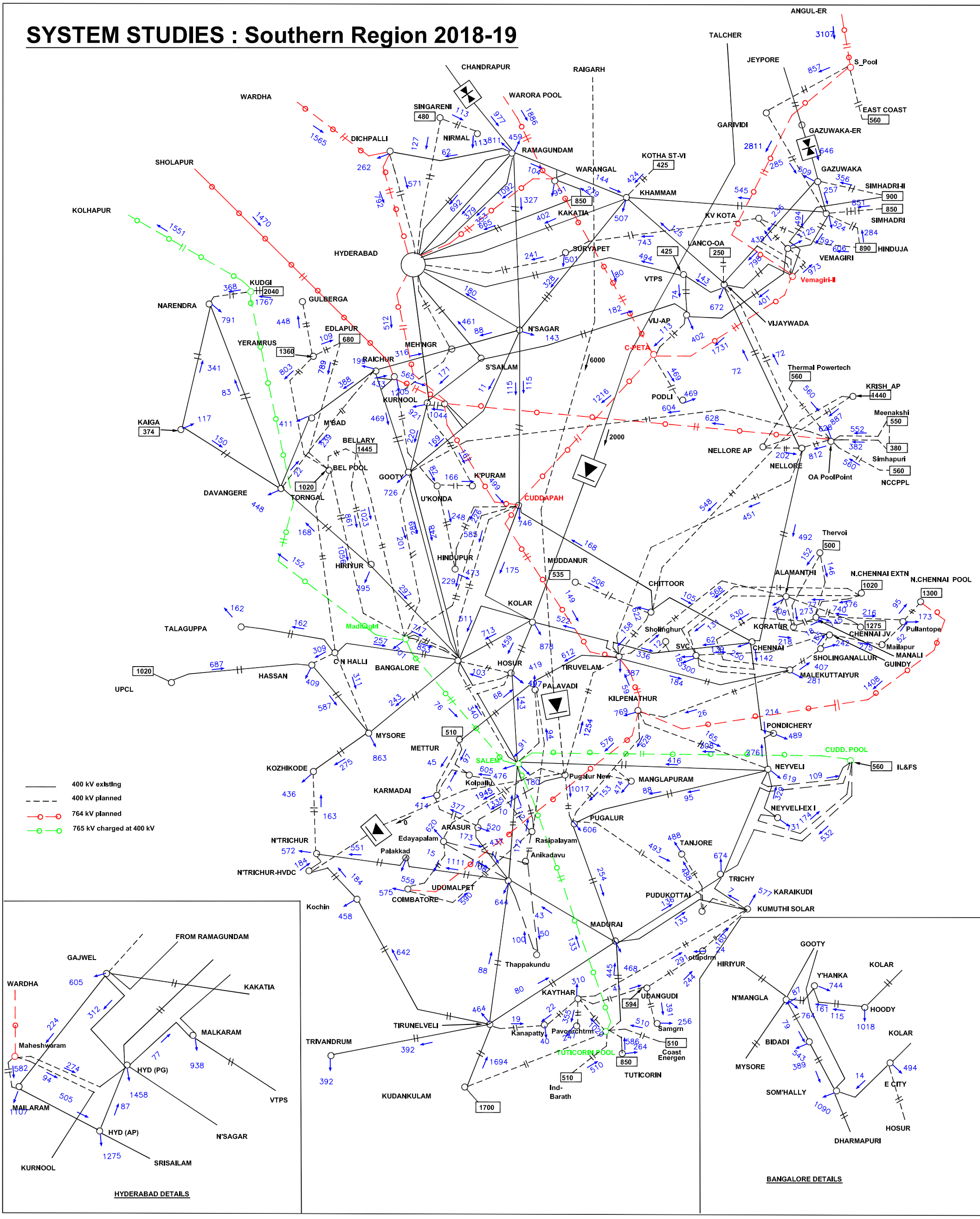
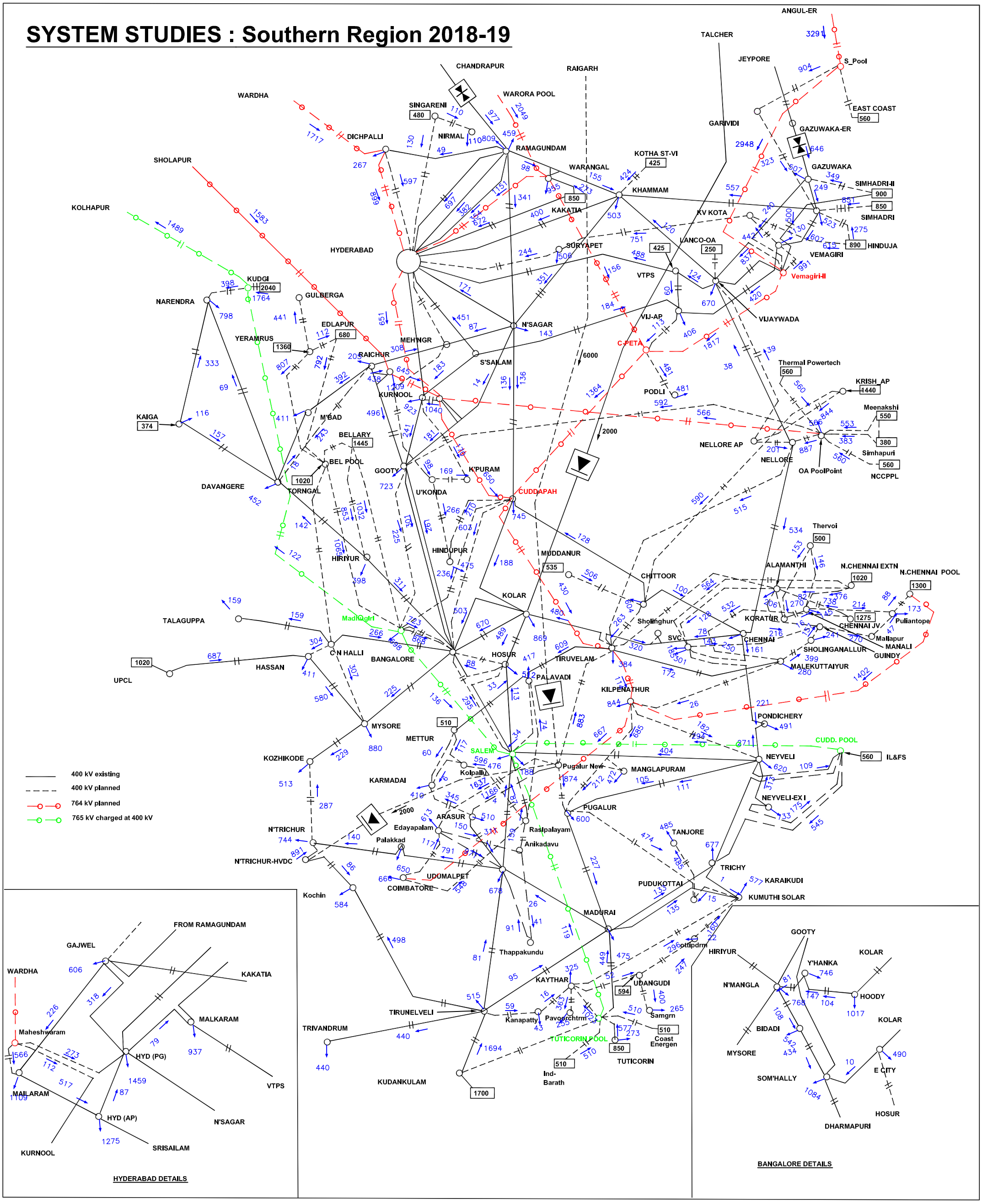


Exhibit - 4

SYSTEM STUDIES : Southern Region 2018-19



Annex IV

Proposed Configuration for 6000MW Raigarh-Pugalur-NorthTrichur HVDC System

20th April, 2015

Proposed Scheme - As per 37th SCM

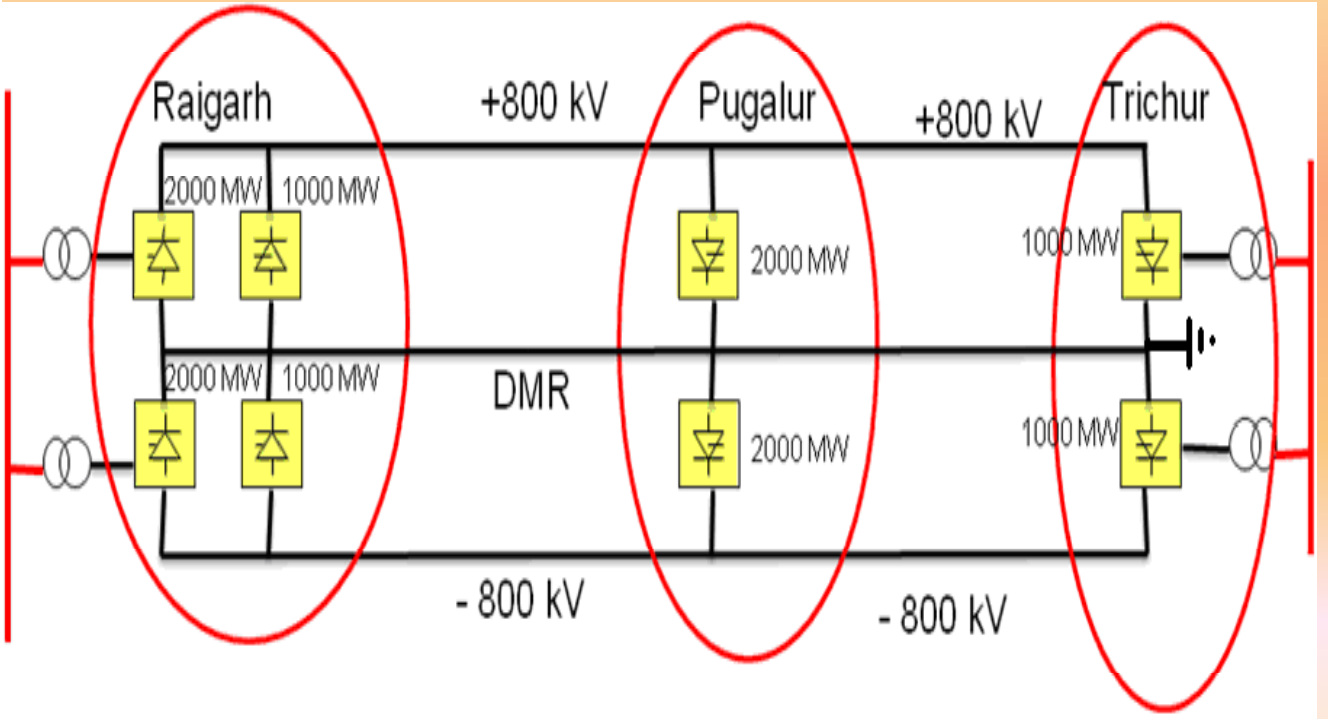
- Alt I- Delivery of bulk power of 6000 MW from Raigarh to Pugalur (Conventional 800 KV HVDC Bipole) or Alt II- Delivery of 4000 MW at Pugalur and 2000 MW at North-Trichur

- MOP vide Letter Dt. 10th Dec, 2014 defined the scope as per ALT II i.e. 4000 MW terminal at Pugalur and 2000 MW terminal at Trichur using 800 KV HVDC Multi Terminal Link

As per SCM & MOP(Alternative-I)

- Establishment of ± 800 kV, 4000 MW (2 x 2000 MW size) HVDC Bipole Terminal each at Raigarh in Chattisgarh and Pugalur (Tamil Nadu).
- Establishment of ± 800 kV, 2000 MW (2x1000 MW size) Parallel Bipole (Multi-Terminal mode) at Raigarh in Chattisgarh and new Bipole at North Trichur (Kerala) in Multi-Terminal mode
- ± 800kV HVDC Line from Raigarh to North Trichur via Pugalur. Line length from Raigarh to Pugalur is 1840 Km and Pugalur to Trichur is 250 Km
- Estimated Cost= Rs 19257 Cr

Alternative-I



Issues in Alternative-I

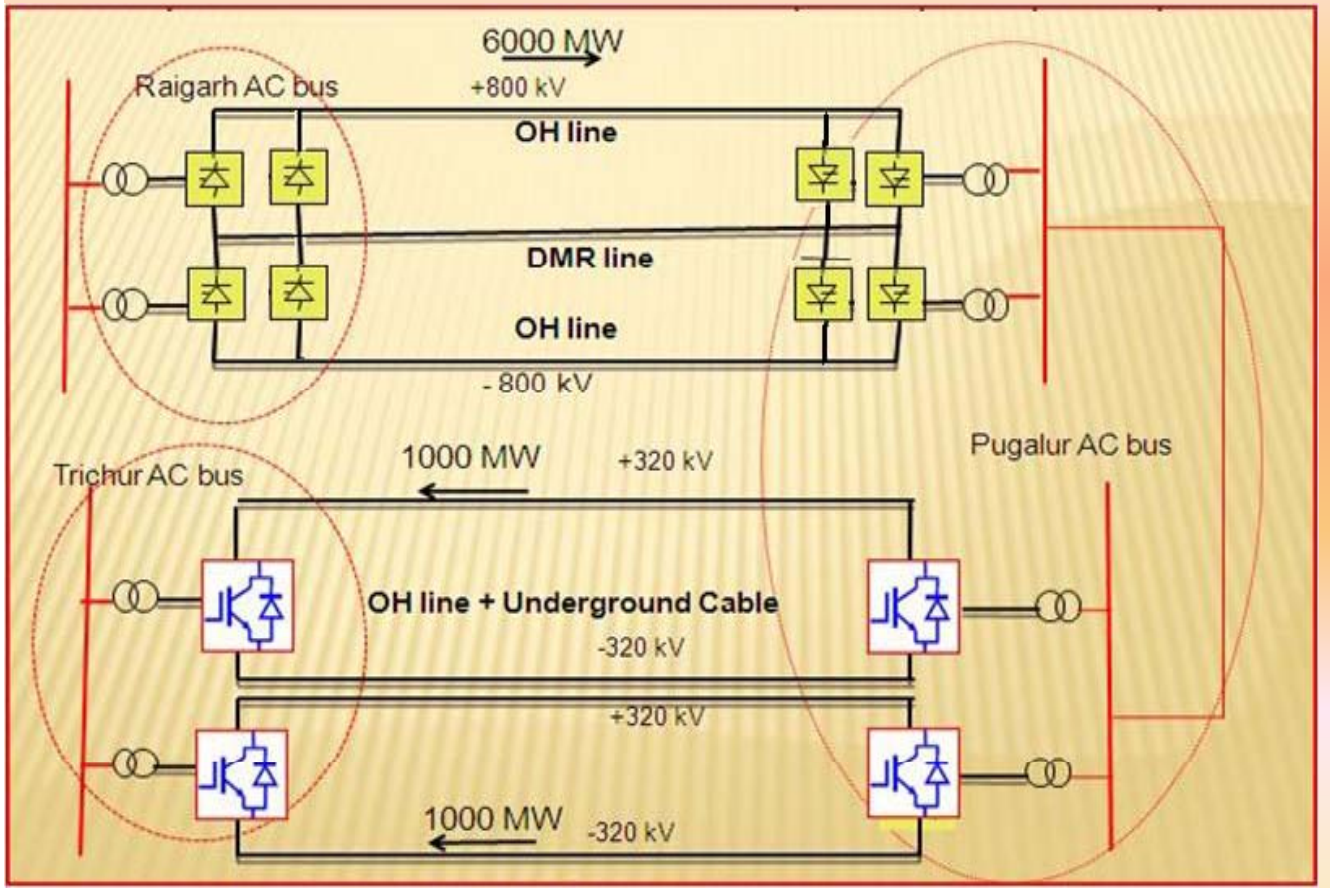
- Right of Way (ROW) 69 m required for ± 800 kV DC system
- ROW problem is anticipated for establishment of ± 800 kV DC transmission system between Pugalur and North Trichur.
- In case Pugalur-North Trichur section is stuck up due to ROW issues like Edamon – Cochin (Stranded for last 7 years)
  - Investment shall be blocked for indefinite period
  - 2000 MW capacity of DC transmission line of 1840 km would remain unused

Present Proposal (Alternative-II)

- Establishment of ± 800 kV, 6000 MW HVDC Terminal (4x1500 MW size) at Raigarh and Pugalur (consisting of two bipoles in parallel) with 1.33 pu continuous overload for each 1500 MW converter.)
- ±800kV HVDC line between Raigarh and Pugalur.
  - Establishment of ± 320 kV, 2000 MW (2x 1000 MW size) VSC Terminal at Pugalur & North Trichur.
  - The connection of Pugalur to N.Trichur by +320 kV HVDC line (apprx. route length 220 km, ROW equivalent to 400 kV D/C) and +320 kV HVDC cable (apprx. route length 33 km, ROW 4 m)
- Estimated cost: INR 19742 Cr (approx.)

Difference in cost Between Alt-II and Alt-I = Rs 485 Cr. (Incremental cost is less than 5% as compared to Alternative-I)

Alternative-II



Salient Features-Alternative-II

- Lesser footprint of the smaller towers used for the +320 kV DC line can address ROW problem
- Lower cost of extruded XLPE cables (3cr/km) can be used with minimal ROW in the route closer to cities and dense habitation where it is difficult to obtain ROW for +320kV overhead line.
- Dynamic voltage support at converter bus at both Pugalur and North Trichur through dynamic compensation.
- Footprint for terminal is less (approx. 50% of LCC of same rating)
- Both LCC (a) and VSC (c) terminals can be controlled separately and can independently offer flexibility.
- Procurement of land may be required along the cable route.

Salient Features-Alternative-II

- For DC line fault scenario between Raigarh –Pugalur Section (± 800 kV DC line of LCC link), Pugalur –North Trichur section shall not be affected for DC power transmission from Pugalur to North Trichur, can address acute RoW issue effectively from Pugalur to North Trichur and offer flexibility in construction, implementation and operation
- Preliminary survey indicates possibility for use of NH 47 corridor for 320 kV HVDC cable routing from Trichur Terminal for upto 33 KMS.

Salient Features-Alternative-II

- Interaction is minimised between two HVDC converters at Pugalur (R+I) with selection of VSC HVDC as compared to LCC between Pugalur and Trichur.
- Effects of variation of large renewable generation in TN are mitigated with VSC HVDC link.
- Full 6000 MW can be transmitted to Southern Region
- VSC technology for HVDC and STATCOM is in commercial use since 2000

ANNEX-V

Manjari Chaturvedi <manjari.cea@gmail.com>

Fwd: Agenda of the Standing Committees on Power System Planning of SR and WR

STU Cell GETCO <stu.getco@yahoo.com> Thu, Apr 16, 2015 at 11:41 AM
Reply-To: STU Cell GETCO <stu.getco@yahoo.com>
To: "manjari.cea@gmail.com" <manjari.cea@gmail.com>, "ravindergupta_cea@rediffmail.com" <ravindergupta_cea@rediffmail.com>, "awd@rediffmail.com" <awd@rediffmail.com>, "kkarya_2001@rediffmail.com" <kkarya_2001@rediffmail.com>, "jindal_pardeep@yahoo.co.in" <jindal_pardeep@yahoo.co.in>
Cc: SE RNC <serc.getco@gebmail.com>, "Deepak DE (STU Cell)" <desystem@gebmail.com>

Dear Sir / Madam,

With reference to your below e-mail regarding Standing Committee Meeting on Power System Planning of SR and WR, we express our inability to attend the scheduled meeting of 20.04.2015.

However, we have no objection for the said agenda from our end.

We regret our absence. Also, kindly inform us outcome of the meeting.

Regards,

S. H. Upadhyay,
Superintending Engineer (STU),
GETCO

> ----- Original Message -----
> **From:** Manjari Chaturvedi
> **To:** ghanshyamprasad@yahoo.com ; kkarya_2001 ; satyaguru@yahoo.com ; ms-wrpc@nic.in ; n.sonkavday@rediffmail.com ; desystem@gebmail.com ; md.getco@gebmail.com ; stu.getco@gebmail.com ; RAKESH MEHTA ; harish_pandey123@rediffmail.com ; sethi.ravi@indiatimes.com ; cestu@mahatransco.in ; eeelectdnh@rediffmail.com ; sureshtaksande@rediffmail.com ; ravindergupta_cea@rediffmail.com ; NARASIMHAN S R ; P Mukhopadhyay {पी. मुखोपाध्याय} ; hpa_seshadri@hotmail.com ; acbpower@acbindia.com ; ks.nagendra@adani.com ; jigar.thakkar@adani.com ; ashok@powergridindia.com ; ramachand@powergridindia.com ; anilsehra@powergridindia.com ; drozekar@powergridindia.com ; ajay.dahiya@powergridindia.com
> **Sent:** Wednesday, April 08, 2015 12:13 PM
> **Subject:** Fwd: Agenda of the Standing Committees on Power System Planning of SR and WR
>
> Sir/ Madam,