File No.CEA-PS-12-14(12)/1/2018-PSPA-II Division

सत्यमेव जयते

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority
विद्युत प्रणाली योजना एवं मूल्यांकन प्रभाग-II
Power System Planning & Appraisal Division-II

सेवा मे / To,

संलग्न सूची के अनुसार
As per list enclosed

विषय: दक्षिणी क्षेत्र के लिए विद्युत प्रणाली योजना पर स्थायी समिति की 42 वीं बैठक की अतिरिक्त कार्यसूची।

Subject: Additional Agenda for 42nd meeting of Standing Committee on Power System Planning for Southern Region.

महोदय(Sir)/महोदया(Madam),

दक्षिणी क्षेत्र के लिए विद्युत प्रणाली योजना पर स्थायी समिति की 42 वीं बैठक 27 अप्रैल, 2018 को 10:00 बजे से होटल क्राउन प्लाजा, एरनाकुलम (केरल) में आयोजित की जायेगी। बैठक की अतिरिक्त कार्यसूची संलग्न है।

The 42nd meeting of the Standing Committee on Power System Planning of Southern Region will be held at 10:00 hrs on 27th April**,** 2018 at Hotel Crown Plaza, Ernakulam (Kerala). Additional Agenda for the meeting is enclosed.

भवदीय/Yours faithfully,

Sd/-

(बी.एस.बैरवा/B.S. Bairwa)
निदेशक/ Director

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Sewa Bhawan, R.K Puram-I, New Delhi-110066 **Telephone**: 011-26198092 **Email**:cea-pspa2@gov.in **Website**: www.cea.nic.in

Address List:

1. The Member Secretary, Southern Regional Power Committee, 29, Race Course Cross Road, **Bangalore 560 009**. **FAX : 080-22259343**	2.The Director (Projects), Power Grid Corp. of India Ltd. "Saudamini", Plot No.2, Sector-29, **Gurgaon 122 001, Haryana**. **FAX : 95124-2571932**
3. CEO, POSOCO, B-9, Qutub Institutional Area, Katwaria Sarai, **New Delhi-110016**	4. The Director (Transmission), Karnataka State Power Trans. Corp.Ltd., Cauvery Bhawan, **Bangalore - 560 009**. **FAX : 080 -22228367**
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 (Trans. & System Op.), Kerala State Electricity Board, Vidyuthi Bhawanam, Pattom, **Thiruvananthapuram - 695 004.** **FAX : 0471-2444738**	8. Member (Distribution), Tamil Nadu electricity Board (TNEB), 6th Floor, Eastern Wing, 800 Anna Salai, **Chennai - 600002.** **FAX : 044-28516362**
9. The Director (Power), Corporate Office, Block – I, Neyveli Lignite Corp. Ltd., **Neyveli , Tamil Nadu – 607 801.** **FAX : 04142-252650**	10. The Superintending Engineer –I, First Floor, Electricity Department, Gingy Salai, **Puducherry – 605 001**. **FAX : 0413-2334277/2331556**
11. Director (Projects), National Thermal Power Corp. Ltd. (NTPC), NTPC Bhawan, Core-7, Scope Complex, Lodhi Road, **New Delhi-110003.** **FAX-011-24360912**	12. Director (Operations), NPCIL, 12th Floor, Vikram Sarabhai Bhawan, Anushakti Nagar, **Mumbai – 400 094.** **FAX : 022- 25991258**

Copy to:

1.	Joint Secretary (Trans) Ministry of Power Shram Shaktri Bhawan Rafi Marg, **New Delhi-110001**	2. COO(CTU-Plg), Power Grid Corp. of India Ltd. "Saudamini", Plot No.2, Sector-29, **Gurgaon 122 001, Haryana**. **FAX : 95124-2571932**
3	ED, SRLDC 29, Race Course Cross Road, Bangalore 560 009 FAX – 080-22268725	

Additional Agenda for 42nd Meeting of Standing Committee on Power System Planning in Southern Region (SCPSPSR)

Date: 27 April, 2018 Time: 10:00 Hrs

Venue: Hotel Crowne Plaza, Ernakulam, Kerala

32. Proposal for interim arrangement for availing quality & stable auxiliary supply for testing at Pugalur HVDC Station

32.1 The Transmission system consisting of high capacity ±800kV, 6000MW HVDC system between Raigarh (Chhattisgarh) and Pugular (Tamil Nadu) was discussed and agreed to meet the growing power transfer requirement of Southern states during the the Joint meeting of the Standing Committee on Power System Planning of Southern Region meeting and Western Region held on 20.04.2015 and 27th meeting of SRPC held on 12.05.2015 (Copy of the relevant extract of the minutes of the meeting is enclosed at **Annexure-XII**). The scheme also includes establishment of VSC based 2000 MW HVDC link between Pugalur and North Trichur (Kerala) for conservation of RoW problem in Kerala and dispersal of power beyond Pugalur. During the joint meeting, it was decided to implement the project in 3 separate schemes as below

a) Scheme # 1 Raigarh-Pugalur 6000 MW HVDC System

b) Scheme # 2 AC System strengthening at Pugalur end

c) Scheme # 3 Pugalur- Trichur 2000 MW VSC Based HVDC System

32.2 As the transmission scheme comprises of large number of elements with different implementation schedules, the schemes are being implemeted in different time frames. Further, the RoW issues in different parts of the transmission lines may effect the commissioing of the elements and therefore all the elements are not expected to be commissioined simultenously and expected to be commisisoned progressively.

32.3 Further, the terminal equipments of Pole-I of Raigarh-Pugalur 6000 MW HVDC link is expected by April, 2019 and the testing & pre-commissioing activities of various equipments including HVDC systems will be commenced from Sep/Oct, 2018. This requires a reliable, stable and quality auxiliary power supply.

32.4 As per the present schedule, 1 no of 200MVA, 400/110/33 kV, ICT along with 400kV GIS bays and corresponding MV and LV system will be ready before September 2018. Further, LT auxiliary supply from the system can be availed once the GIS is charged from 400kV side and that at least one 400kV line emanating from Pugalur HVDC is required to be ready in all respect including 400kV bays at the other end. The 400kV evacuation lines from Pugalur HVDC are as below:

1. Pugalur HVDC Station – Pugalur (Karur) 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
4. Pugalur HVDC Station – Edayarpalayam 400kV (quad) D/c line

However, completing one of the above 400kV lines before September 2018 seems to be very difficult due to sever ROW issues in Tamil Nadu. Therefore, a contigency plan is required for providing stable and quality auxiliary power supply.

32.5 As the New Pugalur – Arasur 400kV D/C line is crossing the existing Udumalpet – Salem 400kV S/C lineat a distance of ~3.6KM from Pugalur HVDC station. The Pugalur – Arasur 400kV D/C line can be implemented upto the crossing point and with suitable arrangement LILO of Udumalpet – Salem 400kV line at Pugalur HVDC Station can be made utilising section of Pugalur – Arasur 400kV D/C line (SLD enclosed at **Annexure-XIII**). This shall facilitate in supply of stable and quality auxiliary power supply for testing and pre-commissioning activities at Pugalur HVDC Station.

32.6 In view of the above an interim arrangement for reliable, stable and quality auxiliary power supply to Pugalur HVDC Station through LILO of Udumalpet – Salem 400kV line at Pugalur HVDC Station utilising section of Pugalur – Arasur 400kV D/C line.

Member may like to deliberate.

33. Proposal for upgradation of transmission system for evacuation of power in Southern Region

33.1 The transmission system comprising of establishment of 2x500 MVA 400/230kV Pooling Station at Tirunelvelli GIS along with its interconnection with Tuticorin Pooling Station through 2 nos. of 400kV D/c lines was envisaged to facilitate interconnection of wind generation in Tirunelveli area with rest of the Grid. The transmission scheme is under advanced stage of commissioning as part of "Green Energy corridor".

33.2 The CTU has received number of Connectivity & LTA applications at the Tirunelveli PS, the details of the same are as below:

Sl. No.	Type of applications	Applications received		Applications granted	
		Numbers	Quantum (MW)	Nos.	Quantum (MW)
1.	Connectivity	20	5700	10	3150
2.	LTA	7	950	4	300

Similarly CTU has also received number of Connectivity & LTA applications at the Pugalur substation, the details of the same are as below:

Sl. No.	Type of applications	Applications received		Applications granted	
		Numbers	Quantum (MW)	Nos.	Quantum (MW)
1.	Connectivity	15	4064	5	1814
2.	LTA	5	640	5	640

The application which are pending for processing are to be processed as per the provisions of "Procedure for Grant of Connectivity to Projects Based on Renewable Sources to Inter-State Transmission System" to be notified by CERC shortly.

33.3 The LTA application at the Tirunelveli PS includes the PPA for 750 MW which has been signed by the wind developers under competitive bidding conducted by SECI under Tranche-I,II & II. In addition, recent bid held by SECI for 2000 MW under Tranche-IV, about 300 MW is also being firmed up in Pugalur and 200 MW in Tirunelveli Area.

33.4 The Tuticorin 765/400kV PS alongwith the Tuticorin – Salem 765kV D/c transmission lines and Salem – Madhugiri 765kV S/c lines initially charged at 400kV levels were established for evacuation of power from Coastal Energen (2x660 MW) and Ind-Barath (1x660 MW). Further Connectivity has been granted to NPCIL for Kudankulam 3&4 (2x1000MW) at Tuticorin PS which has been approved in the 36th Standing Committee meeting of Southern Region held on 04.09.2013.

33.5 With the injection of about 1450 MW of power under LTA and further 2000 MW from Kudankulam St-3&4, the existing transmission system shall be inadequate for evacuation of power of the wind farms/generation projects. The Tirunelveli GIS has can accommodate additional 3x500 MVA transformers making the total transformation capacity of 5x500 MVA of the station and under N-1 contingency of one ICT, 2000 MW of power at Tirunelveli GIS may be injected into the grid. Further 1000 MW of power may be injected at the existing Pugalur substation. However for evacuation of power beyond the injection points and supply of power to the firm/target beneficiaries, upgradation of the transmission corridor of Tuticorin PS-Salem (Dharmapuri)-Vasanthanarsapur (Madhugiri) to its rated voltage of 765kV is required which is presently charged at 400 kV.

33.6 Further looking into the short gestation period of renewable energy sources, it is proposed that transmission corridor beyond Tuticorin PS upto Madhugiri may be upgraded to its rated voltage at 765kV level by charging the substations to their rated voltage at 765 kV level matching with the generation and to enable evacuation of power from wind farms and projects in Southern region.

33.7 Accordingly, following transmission system is proposed:

Substation

a) Upgradation of 765/400kV Tuticorin Pooling Station
   i.) 2x1500 MVA, 765/400kV transformers alongwith associated 765kV & 400kV bays;
   ii.) 2 nos. 765kV line bays for termination of Tuticorin PS – Salem (Dharmapuri) 765kV D/C line.

b) Upgradation of 765/400kV Salem (Dharmapuri) Station
   i.) 2x1500 MVA, 765/400kV transformers alongwith associated 765kV & 400kV bays;
   ii.) 2 nos. 765kV line bays for termination of Tuticorin PS – Salem (Dharmapuri) 765kV D/C line.
   iii.) 2 nos. 765kV line bays for termination of Salem (Dharmapuri) – Vasanthanarsapur (Madhugiri) 765kV D/C line.

c) Upgradation of 765/400kV Vasanthanarsapur (Madhugiri) Station

i.) 2x1500 MVA, 765/400kV transformers alongwith associated 765kV & 400kV bays;
ii.) 2 nos. 765kV line bays for termination of Salem (Dharmapuri) – Vasanthanarsapur (Madhugiri) 765kV D/C line.
iii.) 2 nos. 765kV line bays for termination of Vasanthanarsapur (Madhugiri) – Narendra 765kV D/C line.

d) Upgradation of 765/400kV Narendra substation
i.) 2x1500 MVA, 765/400kV transformers alongwith associated 765kV & 400kV bays;
ii.) 2 nos. 765kV line bays for termination of Vasanthanarsapur (Madhugiri) – Narendra 765kV D/C line.

Transmission lines

a) Charging of Tuticorin PS – Salem (Dharmapuri) to its rated volatage of 765 kV which is presently charged at 400 kV.
b) Charging of Salem (Dharmapuri) – Vasanthanarsapur (Madhugiri) to its rated volatage of 765 kV which is presently charged at 400 kV.
c) Charging of Vasanthanarsapur (Madhugiri) – Narendra to its rated volatage of 765 kV which is presently charged at 400 kV.
d) Charging of Narendra – Kolhapur to its rated voltage of 765 kV which is presently charged at 400 kV.

Member may like to deliberate.

34. High voltage system studies and proposal for reactive compensation in SR

34.1 CTU has carried out reactive compensation study of Southern Region. The detailed study report is enclosed at **Annexure -XIV**

34.2 Members may discuss.

35. Establishing 2x100 MVA, 220/66 kV substation at Hosadurga- Revision in 220kV scheme to be included under GEC Phase 1

35.1 The Proposal for establishing 2x100 MVA, 220/66 kV sub-station at Hosadurga, Chitradurga District is included under Green corridor transmission phase 1 projects. Earlier the project was approved in 38th Meeting of Standing Committee of Power System Planning of Southern Region held on 28th-29th December, 2015 with 220 kV incoming linefrom proposed 400/220 kV CN Halli sub-station.

35.2 KPTCL informed that the land acquisition for the proposed 400/220kV Chikkanayakanahalli is still under. process. The work of 220 kV line between CN Halli and proposed Hosadurga will be taken up at later stage.

35.3 KPTCL has proposed to include Hosadurga-Benikere 220kV D/C line in the package.

35.4 Members may discuss.

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*

MINUTES OF MEETING

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 ±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.

भारत सरकार

GOVERNMENT OF INDIA

विद्युत मंत्रालय

MINISTRY OF POWER

केंद्रीय विद्युत प्राधिकरण

CENTRAL ELECTRICITY AUTHORITY

दक्षिण क्षेत्रीय विद्युत समिति

SOUTHERN REGIONAL POWER COMMITTEE

सत्ताईसवीं बैठक की कार्यवृत

MINUTES OF THE 27TH MEETING

बेंगलूरु

BENGALURU

switched capacitors had been planned at Jeypore 400 / 220 kV SS. The same is expected to be commissioned in the next 2-3 years. It would therefore take 2-3 years to enhance the ATC of Jeypore-Gazuwaka link to its rated capacity

3.13.4 KSEBL vide letter dated 04.05.2015 (refer item No.8 of **Annexure-IV)** had stated that even though Gazuwaka B2B HVDC poles connecting ER and SR is having a total transfer capacity of 1000 MW, which cannot be used effectively due to low voltage problem in Gazuwaka East Bus associated with its low fault level. Hence in the existing condition, available power transfer of the order of only 650 MW can be enabled.

3.13.5 The following had been noted in the TCC Meeting:

- SRLDC had stated that in the present Grid scenario due to low short circuit level of Gazuwaka and upstream line loadings in GRIDCO system power up to 750 MW only could be imported.
- MS, SRPC had informed that CTU had intimated that STATCOM along with mechanically switched reactors/capacitors were planned to be commissioned in 2 to 3 years time frame which would then stabilize voltage variation at Jeypore.
- PGCIL had stated that non-commissioning of the Talcher Backup Scheme by Reliance Power Transmission Ltd. (RPTL) was also leading to the non-utilization of the HVDC B2B station to its full capacity.
- TSTRANSCO had expressed concern that the link capacity needed to be utilized fully and some short term measures need to be identified. This could also involve shifting of any STATCOM from other parts of the country to Gazuwaka.
- After deliberations, it was decided that the issue be further discussed in the second Meeting of the Task Force.

SRPC noted the above.

4. TRANSMISSION LINES APPROVED IN 38th MEETING OF SCPSPSR

4.1 The 38th Meeting of Standing Committee on Power System Planning of Southern Region (SCPSPSR) was held on 7th March 2015. The Minutes of the Meeting is available at CEA website:

http://www.cea.nic.in/reports/powersystems/sppa/scm/sr/agenda_note/joint_08042015.pdf.

4.2 In the 38th Meeting of SCPSPSR, PGCIL had proposed modifications in the scope of HVDC terminals at Pugalur and North Trichur in addition to the set of 6000 MW terminals at Raigarh and Pugalur. Also the Pugalur – N Trichur terminals had been proposed to be built with VSC based technology instead of the earlier

conventional HVDC technology. In this regard, a Joint Meeting of the Standing Committees of Power System Planning of SR &WR was conducted on 20th April 2015 at New Delhi.

4.3 The following had been noted in the TCC Meeting:

- The schemes finalized/discussed during the 38th Meeting of SCPSPSR.
- KSEBL had suggested that overload capacity for short duration for Raigarh- Pugalur HVDC link be explored to take care of N-1 contingencies, keeping in view the experience in HVDC Talcher-Kolar link.
- PGCIL had endorsed the view of KSEBL and stated that overload capacity of 33 1/3%for Raigarh- Pugalur HVDC link would take care of any N-1 contingency. The rated capacity would remain as 6,000 MW. Additional expenditure for this purpose would be roughly around Rs.150 crores only based on Talcher-Kolar up gradation experience.
- After deliberations, TCC recommended that for Raigarh-Pugalur HVDC link PGCIL could consider overload capacity of 33 1/3% which would take care of any N-1 contingency. PGCIL to take up with Standing Committee for ratification.

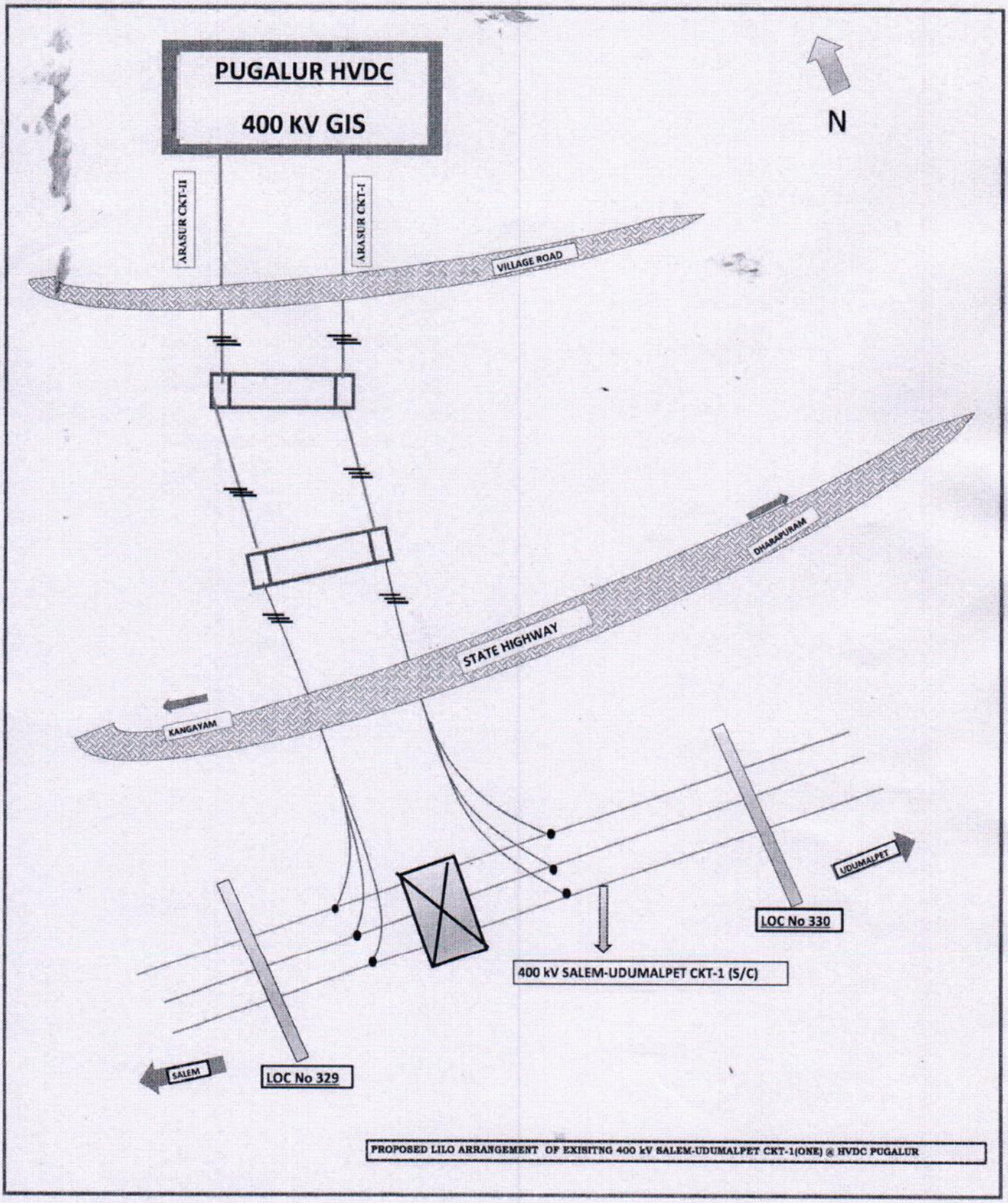
4.4 In the Meeting, SRPC approved that for Raigarh-Pugalur HVDC link PGCIL could consider overload capacity of 33 1/3% which would take care of any N-1 contingency. PGCIL to take up with Standing Committee for ratification in this regard.

5. NEW PROJECTS OF NTPC, NLC, NPCIL, JOINTVENTURE& UMPP

5.1 NTPC- Kudgi TPS Stage-I (3x 800 MW)

5.1.1 In the 26th Meeting of SRPC, the following had been noted:

- NTPC had informed that Unit-I synchronization was planned for February 2016 while CoD was expected by April 2016. CoD of Unit –II was expected subsequently after 6 months.
- CTU had informed that AP DISCOMs (undivided) were having share of 418 MW. After reorganization, revised application for LTA was needed to be furnished by NTPC/AP /Telangana.
- TSTRANSCO had informed that sharing percentage as per the AP Reorganization Act 2014 holds good for any project under construction also. They would ensure the needful in coordination with NTPC.
- Director (Grid & Tr), APTRANSCO had stated that any sharing would need to be carried out as per the Reorganization Act 2014.


PUGALUR HVDC
400 KV GIS
N
ARASUR CKT-II
ARASUR CKT-I
VILLAGE ROAD
DHARAPURAM
STATE HIGHWAY
KANGAYAM
UDUMALPET
LOC No 330
400 kV SALEM-UDUMALPET CKT-1 (S/C)
SALEM
LOC No 329
PROPOSED LILO ARRANGEMENT OF EXISITNG 400 kV SALEM-UDUMALPET CKT-1(ONE) @ HVDC PUGALUR

High Voltage Phenomena in Southern Region

A Study Report

Power Grid Corporation of India Ltd.
Gurugram
April, 2018

System Studies for Analysis of High Voltage conditions in Southern Regional Grid

1.0 Back Ground : The NLDC under its operational feedback on Transmission constraints for Quarter 1, 2 & 3 of 2017-18 has stated that persistent high voltage situation is being experienced 20-70% of time in the off-peak period at number of 765/400 kV substations in the Southern Regional grid and to control voltages within acceptable limits, tripping of parallel circuits of high voltage 765kV & 400kV lines were resorted to. Further despite opening of the lightly loaded lines, high voltage is observed at nos of substations for substantial period of time.

The details of the substations facing high voltage situations are as given below:

Table : 1

Sl. No.	Node	Description of the constraints	Quarter in which high voltage was experienced
1	400kV Vijayawada SS	Voltages remain very high most of the time	Q2, Q3, Q4
2	400kV Gooty SS	Voltages remain very high most of the time	Q2, Q3, Q4
3	400kV Kurnool SS	Voltages remain very high most of the time	Q2, Q3, Q4
4	400kV Sattenapally	Voltages remain very high most of the time	Q2, Q3, Q4
5	400kV Hyderabad SS	Voltages remain very high most of the time	Q2, Q3, Q4
6	400kV Mamidipally	Voltages remain very high most of the time	Q2, Q3, Q4
7	400kV Srisailam LB	Voltages remain very high most of the time	Q2, Q3, Q4
8	400kV Malkaram SS	Voltages remain very high most of the time	Q2, Q3, Q4
9	400kV Karaikudi SS	During Low wind condition and off-peak condition Voltages are very High	Q2, Q3, Q4
10	765kV Raichur SS	Voltages remain very high most of the time	Q2, Q3, Q4
11	765kV Kurnool SS	Voltages remain very high most of the time	Q2, Q3, Q4
12	400kV Urvakonda SS	Voltages remain very high most of the time	Q2, Q3, Q4
13	400kV Ghani SS	Voltages remain very high most of the time	Q2, Q3, Q4
14	400kV Jamalamadugu	Voltages remain very high most of the time	Q2, Q3, Q4
15	400kV Dindi SS	Voltages remain very high most of the time	Q2, Q3, Q4
16	400kV K V Kota SS	Voltages remain very high most of the time	Q3, Q4
17	400kV Suryapet SS	Voltages remain very high most of the time	Q3, Q4
18	400kV Veltoor	Voltages remain very high most of the time	Q3, Q4
19	400kV Kaiga SS	During Low generation period and off-peak period 400kV Narendra Voltage are High	Q3, Q4
20	400kV Hassan SS	Voltages remain very high most of the time	Q3, Q4
21	400kV Talaguppa SS	During Low generation period and off-peak period 400kV Narendra Voltage are High.	Q3, Q4
22	400kV Thiruvallam SS	Voltages remain very high most of the time	Q3, Q4
23	400kV Udumalpet SS	During Low wind condition and off-peak condition Voltages are very High	Q3, Q4
24	765kV Srikakulam SS	Voltages remain very high most of the time	Q3, Q4

Sl. No.	Node	Description of the constraints	Quarter in which high voltage was experienced
25	765kV Thiruvallam SS	Voltages remain very high most of the time	Q3, Q4
26	400kV Mahboobnagar	Voltages remain very high most of the time	Q2
27	400kV Bhoopalapally	Voltages remain very high most of the time	Q2
28	400kV Singereni SS	Voltages remain very high most of the time	Q2
29	400kV Narendra SS	During Low generation period and off-peak period 400kV Narendra Voltage are High	Q2

As per the Quarter – 3 NLDC Operational feedback, the transmission lines which were taken out of service to control high voltages is enclosed at Annexure-I, wherein it is observed that about 64 nos of 765 and 400 kV lines were opened on 1289 nos of occasions. However, on close examination it is seen that out of these 1289 nos, 23 nos of lines corresponding to 572 nos of occasions are those lines that are directly emanating from generating stations or are consequential for evacuation of power from generating stations. Now if generating station is not generating power for any reason then it makes sense that the direct evacuation line is switched tripped to avoid the line from injecting unwanted VARs into the system.

From the above, it is apparent that the situation of high voltage in the southern regional grid is due to the less utilization of the high voltage transmission lines especially under the off-peak load conditions. Under this scenario renewable resources in the southern region generate to the fullest of their capacity and inject power at lower voltage levels and meet the nearby load centers and thereby the high capacity transmission lines implemented for import of power from NEW Grid under the peak-load conditions remain less utilized and therefore contributes injection of additional reactive power into the system and contributes in increased voltage levels at the substations. Further the transmission system under the STU network has also been strengthened by the respective States, however they have not provided the sufficient reactive compensation to take care of the same under off-peak conditions.

Voltage, unlike frequency, is a local phenomenon, which means that the voltage profile essentially is a local balance of reactive power as reactive MVARs are difficult to transfer over large distances. Further, this situation varies over a large spectrum of scenarios like, high renewable energy generations, seasonal variations

including water availability in reservoirs, hydro generations, agricultural loads, export/import requirements etc. Generally the tools available for control of high voltages during off-peak scenario includes absorption of VARs by generators, switching in-service to the bus reactors, transformer taps changing, tripping of lightly loaded transmission lines, usage of power flow regulation facility of HVDC systems etc. Adoptions of any or some of these tools are case specific and there can not be single formulae applicable to all and every situation. Therefore, generic analysis applicable to most of the situations shall have to be made to counter most of the likely situations and specific scenarios can be analyzed separately on case to case basis.

Accordingly, this report attempts to address the high voltages at substations refereed by POSOCO under the generic off-peak situation through analysis of various options for their effectiveness and to propose long term solution.

2.0 High Voltage Condition Manifestation

The voltage profile of the grid at any point of time is governed by the reactive power balance at any particular grid point, availability of surplus VARs results in high voltage conditions and deficiency of VARs results into low voltage conditions. All the active and passive elements of electrical grid possess individual characteristics with regard to the VARs supply / absorption:

Reactive Sources	Reactive power Sinks
Capacitors	Reactors
Generators running in lagging mode	Generators under leading mode
Lightly loaded transmission lines (lines loaded less than SIL i.e. about 500 MW for uncompensated 400 kV and 125 MW for 220 kV lines)	Heavily loaded transmission lines

Based on the grid conditions at any given point of time these elements have to be switched-off or brought into the service to satisfy the reactive power balance and to keep voltages under acceptable limits.

From the above, it is clear that the high voltage situation typically occurs during off-peak conditions when the load demand in the grid is minimum and a large number of units especially hydro (to conserve water for peak time) are taken out of service and the must run renewable energy sources are in-service which do not provide any reactive power support. The high voltage situations is manifested due to following events

- Under the off-peak conditions whatever be the remaining generation units do not permit absorption of the VARs by keeping terminal voltages through AVR adjustment. Thereby the generators themselves causing the widespread high voltage around the vicinity.
- Renewable generation being the must run character, as per the availability of the solar or wind, generate power whether it is absorbed or not and all the more do not have any reactive power absorption capability.
- The EHV stations are generally planned and implemented with the switchable Bus Reactor for absorption of the VARs under the off-peak conditions, however with the growth of the grid the effect of these reactors become minimal.
- The lightly loaded transmission lines below their SIL limits generates reactive power and injects into the system which leads to the increase bus voltages.
- The shunt capacitors are generally provided at the low voltage level (sub-transmission / distribution level) to provide VAR support during peak conditions especially where the loads are reactive power intensive like agricultural pumps, heavy industries etc. However, when the load demand from those substations is reduced, it is required that these capacitors are switched off to avoid pumping of VARs into the high voltage grid.

3.0 Analysis of the High Voltage Conditions prevailing in Southern Region

Southern Regional grid presently has generation installed capacity of 91,100 MW and peak demand of 47,300 MW. Further the during off peak conditions Southern Regional grid experiences a demand variation of about 40% during the day apart from seasonal variation. The minimum monthly demand on the regional basis observed for the past 12 months is as given below:

Table - 2

Sl. No.	Month	Date	Minimum Demand (MW)
1.	Apr, 17	17-04-2017	32,087
2.	May, 17	08-05-2017	28,117
3.	Jun, 17	26-06-2017	26,206
4.	Jul, 17	16-07-2017	27,938
5.	Aug, 17	20-08-2017	27,390
6.	Sept, 17	18-09-2017	25,125
7.	Oct, 17	02-10-2017	25,982
8.	Nov, 17	06-11-2017	28,004
9.	Dec, 17	03-12-2017	27,443
10.	Jan, 18	15-01-2018	28,368
11.	Feb, 18	04-02-2018	31,390

The voltage profile of major 400 kV stations as available on the SRLDC web site is enclosed at **Annexure-I**. It may be observed that the grid is witnessing large voltage variations over a day on daily basis.

Further as per the MNRE, tentative installed capacity of Wind/Solar energy by the year 2022 in SR shall be about 55 GW. However, Wind/Solar shall not be able to provide reactive power support as that of conventional generation. In SR region RE generation will be maximum during off peak condition. High RE generation in off peak condition along with low conventional generation with in region will necessitate adequate reactive compensation requirement for secure and reliable grid. During non-availability of wind/solar generation, transmission lines pertaining to green energy evacuation shall be lightly loaded and shall inject reactive power into the grid to increase bus voltages. Therefore it become imperative to consider reactive compensation scheme for the region as a whole.

Accordingly reactive compensation studies has been carried out for present as well as 2021-22 time frame, under off peak condition, to analyze the nodes experiencing high voltage in Southern Region. The nodes with the voltages more than 420kV in 400kV system and 800kV in 765kV system has been considered as over voltage.

Under the planning criteria, the reactive power limits (Q_{max} and Q_{min}) for generator bus are considered as 50% and -10% of P_{max} for thermal and nuclear units. However from capability curve of the generators it has been noticed that generators have reactive power absorption capability of approximately -35% of P_{max}. To keep the margin in planning stage, Q_{min} in the studies has been considered as -15% of P_{max}.

3.1 System Study – Present Condition

The Load Generation Balance considered for the present time frame for Southern region is as given below:

Demand : 33,100 MW

Despatch of power from generation within SR : 26,500 MW

Import of power from neighboring regions : 7700 MW

	FROM ------AT AREA BUSES-------				TO				-NET INTERCHANGE-		
	GENE-	FROM IND	TO IND	TO	TO BUS	GNE BUS	TO LINE	FROM	TO	TO TIE	TO TIES	DESIRED
X-- AREA --X	RATION	GENERATN	MOTORS	LOAD	SHUNT	DEVICES	SHUNT	CHARGING	LOSSES	LINES	+ LOADS	NET INT
5	26465.6	0.0	0.0	33123.3	0.0	0.0	0.0	0.0	1114.9	-7772.6	-7772.6	0.0
SOUTH	-3657.6	0.0	0.0	10667.5	7756.4	0.0	11505.5	44227.2	11249.4	-609.3	-609.3	
COLUMN	26465.6	0.0	0.0	33123.3	0.0	0.0	0.0	0.0	1114.9	-7772.6	-7772.6	0.0
TOTALS	-3657.6	0.0	0.0	10667.5	7756.4	0.0	11505.5	44227.2	11249.4	-609.3	-609.3	

From the study results under the Base Case, following buses are observed with the high voltages. From table 1 & 3, it may be observed that the buses informed by NLDC in its operational feedback are also appearing the studies:

Table: 3

Sl. No.	Bus Name	ISTS /STATE	Bus level (kV)	Voltage observed (KV)
1	KURNOOL-PG	ISTS	765	825
2	TIRUVALAM	ISTS	765	818
3	RAICHUR-PG	ISTS	765	816
4	NELLORE-PS	ISTS	765	814
5	JAMALAMADUGU	TEL	400	435
6	URAVAKONDA	AP	400	435
7	KURNOOL-PG	ISTS	400	429
8	KURNOOL	AP	400	429
9	GHANI	AP	400	429
10	K V KOTA	AP	400	428
11	SRISAILAMLB	TEL	400	427
12	SURYAPET	TEL	400	424
13	SATTENAPALLI	AP	400	424

Sl. No.	Bus Name	ISTS /STATE	Bus level (kV)	Voltage observed (KV)
14	ASUPAKA	AP	400	424
15	RAICHUR-PG	ISTS	400	423
16	VELTOOR	TEL	400	423
17	GOOTY	ISTS	400	423
18	VTS-IV	AP	400	422
19	DINDI	TEL	400	422
20	RAICHUR TPS	KAR	400	421
21	MEENAKSHI	ISTS-IPP	400	421
22	SIMHAPURI	ISTS-IPP	400	421
23	GAUTHAMI	AP	400	421
24	NELLORE-PS	ISTS	400	421
25	KONASEEMA	AP	400	420
26	VEMAGIRI	AP	400	420
27	GMR	AP	400	420
28	NELLORE-PG	ISTS	400	420
29	NELLORE-AP	AP	400	420
30	GVK-II	AP	400	420

In above base case, the transmission lines emanating from the generation projects which are not generating any power were taken out of service and in such condition following buses are observed with the high voltages:

Table - 4

Sl. No.	Bus Name	ISTS /STATE	Bus level (kV)	Voltage observed (KV)
1	KURNOOL-PG	ISTS	765	814
2	TIRUVALAM	ISTS	765	810
3	RAICHUR-PG	ISTS	765	806
4	NELLORE-PS	ISTS	765	804
5	JAMALAMADUGU	AP	400	425
6	URAVAKONDA	AP	400	423
7	KURNOOL-PG	ISTS	400	422
8	KURNOOL	AP	400	421
9	GHANI	AP	400	420

From the above, it is observed that with the opening of transmission lines emanating from non-generating power stations and few of the grid lines on case to case basis, the voltage control may be managed. Hence, no immediate action is required for reactor installation.

3.2 System Study – 2021-22 Condition

The Load Generation Balance considered for 2021-22 time frame under off-peak conditions for Southern region alongwith the approved bus & line reactors is as given below:

Demand : 37,000 MW (60% of Peak Load)

Despatch of power from generation within SR : 28,500 MW

Import of power from neighboring regions : 9200 MW

AREA TOTALS

IN MW/MVAR

X-- AREA --X	FROM GENE-RATION	FROM IND GENERATN	TO IND MOTORS	TO LOAD	TO BUS SHUNT	TO GNE BUS DEVICES	TO LINE SHUNT	FROM CHARGING	TO LOSSES	-NET INTERCHANGE- TO TIE LINES	TO TIES + LOADS	DESIRED NET INT
5	28578.2	0.0	0.0	37062.0	0.0	0.0	0.0	0.0	749.8	-9233.6	-9233.6	-6200.0
SOUTH	-9230.5	0.0	0.0	12179.3	21346.6	0.0	21772.0	74603.3	8981.4	1093.6	1093.6	
COLUMN	28578.2	0.0	0.0	37062.0	0.0	0.0	0.0	0.0	749.8	-9233.6	-9233.6	-6200.0
TOTALS	-9230.5	0.0	0.0	12179.3	21346.6	0.0	21772.0	74603.3	8981.4	1093.6	1093.6	

Further, for the above conditions Mvar injection into the system from lightly / no loaded lines become so high that to converge the case, Generator is required to set with Q_{min} at -20%. In addition to that 16 nos. of bus reactors of 125 MVar, 400kV each is also required to converge the case. Detail list of the bus rectors required for converging the base case in time frame of 2021-22 are as below :

Table : 5

Sl. No.	Bus Name	Voltage (in kV)	ISTS / STATE	Existing / UC BUS Reactor (MVAr)	BUS Reactor required for at-least converging the case (MVAr)
1.	HOSUR	400	ISTS	63	125
2.	MADHUGI	400	ISTS	63	125
3.	DHARAMPURI	400	ISTS	-	125
4.	RACHAGUNNERI	400	AP	-	125
5.	SURYPET	400	TEL	-	125
6.	RAIDURG	400	TEL	-	125
7.	KAMALAPURAM	400	TEL	-	125
8.	NARSAPUR	400	TEL	-	125
9.	MAHESHWARAM-TS	400	TEL	-	125
10.	TIPPAPUR	400	TEL	-	125
11.	MANIKONDA	400	TEL	-	125
12.	JANAGAON	400	TEL	-	125

Sl. No.	Bus Name	Voltage (in kV)	ISTS / STATE	Existing / UC BUS Reactor (MVAr)	BUS Reactor required for at-least converging the case (MVAr)
13.	CHOUTTUPPAL	400	TEL	-	125
14.	YELLAMPALLI	400	TEL	-	125
15.	YERAMARUS	400	KAR	-	125
16.	BELLARY PS	400	KAR	-	2x125

Base Case : Under the base case, from the study results, following buses are observed with high voltage (>420kV) in SR:

BUSES WITH VOLTAGE GREATER THAN 1.0500:

BUS#	X-- NAME --X	BASKV	AREA	V(PU)	V(KV)	BUS#	X-- NAME --X	BASKV	AREA	V(PU)	V(KV)
504007	CUDDAPAH	400.00	5	1.0559	422.38	504008	GOOTY	400.00	5	1.0566	422.62
504013	KURNOOL4	400.00	5	1.0516	420.66	504028	KURNOOL-NEW	400.00	5	1.0508	420.33
504032	PANYAM	400.00	5	1.0512	420.47	504042	HINDUPUR	400.00	5	1.0776	431.02
504050	NPKUNTA	400.00	5	1.0661	426.44	504082	MAILAVARAM	400.00	5	1.0592	423.70
504083	TALARICH	400.00	5	1.0614	424.58	504087	URAVAKONDA2	400.00	5	1.0659	426.35
504132	KONDAPURAM	400.00	5	1.0601	424.04	504133	URAVAKONDA	400.00	5	1.0675	426.98
514068	RAIDURG	400.00	5	1.0584	423.35	514069	RAIDURG DUMY	400.00	5	1.0576	423.06
514131	MANIKONDA	400.00	5	1.0512	420.50	514173	UDDANDAPUR	400.00	5	1.0509	420.35
524001	SMNH	400.00	5	1.0527	421.07	524002	MNRB	400.00	5	1.0515	420.61
524004	DAVAN4	400.00	5	1.0525	421.01	524005	HOODI4	400.00	5	1.0568	422.74
524006	TALAGUP4	400.00	5	1.0566	422.63	524007	NELMANG4	400.00	5	1.0630	425.18
524008	UDUPI400	400.00	5	1.0545	421.82	524009	HASSAN4	400.00	5	1.0756	430.25
524010	MYSORE4	400.00	5	1.0789	431.56	524011	KOLAR	400.00	5	1.0593	423.70
524025	DHANLLI	400.00	5	1.0588	423.52	524044	HIRY	400.00	5	1.0698	427.93
524048	DHONI4	400.00	5	1.0545	421.80	524050	JAGALUR4	400.00	5	1.0898	435.93
524076	TORNGL4	400.00	5	1.0642	425.67	524077	BIDADI	400.00	5	1.0566	422.63
524082	BELLARY	400.00	5	1.0588	423.51	524084	YELAHNKA	400.00	5	1.0574	422.95
524086	BELLARY-POOL	400.00	5	1.0651	426.04	524087	TUMKUR SP	400.00	5	1.0688	427.51
524097	CNHALLI	400.00	5	1.0900	435.99	524098	MADHUGI4	400.00	5	1.0621	424.82
524169	PEENYA4	400.00	5	1.0614	424.55	534003	KOZIKODE4	400.00	5	1.0591	423.66
534049	KASRGODE4	400.00	5	1.0726	429.03	534857	WAYANAD4	400.00	5	1.0761	430.45
544013	PUGALUR4	400.00	5	1.0541	421.64	544014	ARASUR4	400.00	5	1.0509	420.34
544016	PUGALUR-NEW	400.00	5	1.0548	421.93	544017	KARAIKUDI	400.00	5	1.0546	421.82
544063	VELALAVIDU	400.00	5	1.0574	422.96	544093	TAPPAKUNDU	400.00	5	1.0532	421.26
544094	ANIKADAV	400.00	5	1.0512	420.48	544097	RASIPALAYAM	400.00	5	1.0503	420.12
544113	DHARMAPURI	400.00	5	1.0540	421.61	544132	KAMUTHI4	400.00	5	1.0504	420.17
544999	VIRUDHNAGAR	400.00	5	1.0523	420.92	548999	VIRUDHNAGAR	765.00	5	1.0504	803.52

Table :6

Sl. No.	BUS Name	ISTS/STU	Voltage level (kV)	Voltage Observed (kV)
1	VIRUDHNAGAR	TN	765	804
2	CNHALLI	KAR	400	436
3	JAGALUR	KAR	400	436
4	MYSORE	ISTS	400	432
5	HINDUPUR	AP	400	431
6	WAYANAD	KER	400	430
7	HASSAN	ISTS	400	430
8	KASRGODE	KER	400	429

Sl. No.	BUS Name	ISTS/STU	Voltage level (kV)	Voltage Observed (kV)
9	HIRIYUR	ISTS	400	428
10	TUMKUR SP	ISTS	400	428
11	URAVAKONDA	AP	400	427
12	NPKUNTA	ISTS	400	426
13	URAVAKONDA2	AP	400	426
14	BELLARY-POOL	KAR	400	426
15	TORNGL	KAR	400	426
16	NELMANGLA	KAR	400	425
17	MADHUGIRI	ISTS	400	425
18	TALARICH	AP	400	425
19	PEENYA	KAR	400	425
20	KONDAPURAM	AP	400	424
21	MAILAVARAM	AP	400	424
22	KOLAR	ISTS	400	424
23	KOZIKODE	KER	400	424
24	DHNLLI	KAR	400	424
25	BELLARY	KAR	400	424
26	RAIDURG	TEL	400	423
28	VELALAVIDU	TN	400	423
29	YELAHNKA	ISTS	400	423
30	HOODI	KAR	400	423
31	TALAGUP	KAR	400	423
32	BIDADI	ISTS	400	423
33	GOOTY	ISTS	400	423
34	CUDDAPAH	ISTS	400	422
35	PUGALUR-NEW	ISTS	400	422
36	UDUPI	KAR	400	422
37	KARAIKUDI	ISTS	400	422
38	DHONI	KAR	400	422
39	PUGALUR	ISTS	400	422
40	DHARMAPURI	ISTS	400	422
41	TAPPAKUNDU	TN	400	421
42	SOMANHALLI	ISTS	400	421
43	DAVANGIRI	KAR	400	421
44	VIRUDHNAGAR	TN	400	421
45	KURNOOL	AP	400	421
46	MUNIRABAD	ISTS	400	421
47	MANIKONDA	TEL	400	421
48	ANIKADAV	TN	400	420
49	PANYAM	AP	400	420

Sl. No.	BUS Name	ISTS/STU	Voltage level (kV)	Voltage Observed (kV)
50	UDDANDAPUR	TEL	400	420
51	ARASUR	ISTS	400	420
52	KURNOOL-NEW	ISTS	400	420
53	KAMUTHI	TN	400	420
54	RASIPALAYAM	TN	400	420

From the study results, it may be observed that as compared to Table-3 for present time frame, where there are only 9 nos of substations with high voltages, under 2021-22 time frame the more than 50 substation with high voltages has been observed, the detail given in Table-6, despite considering 16X125 Mvar bus reactors along with Q_{min} -20% support of Generators (-15% in present time frame) in advance.

Case-1 : As light loaded lines inject more Mvar into the system and are the main contributors of the high voltage into the system. Accordingly, all possible one circuit of the 400kV D/c lightly loaded lines which are connecting to high voltage bus has been put out of service. The detailed list of lines put out of service and then the substations experiencing high voltages despites of that are given below.

```
BRANCHES WITH DIFFERENT SERVICE STATUS OR IN ONE CASE ONLY:
                                                        IN WORKING CASE     IN
C:\Users\...\Desktop\SR\2020-21_base case with Proposed Reactors_R2.sav
 X------- FROM BUS --------X X-------- TO BUS ---------X CKT    STATUS      STATUS
 504007 [CUDDAPAH    400.00] 504050 [NPKUNTA     400.00]  2        1           0
 504032 [PANYAM      400.00] 504132 [KONDAPURAM  400.00]  1        1           0
 504042 [HINDUPUR    400.00] 504050 [NPKUNTA     400.00]  1        1           0
 504083 [TALARICH    400.00] 504132 [KONDAPURAM  400.00]  1        1           0
 504083 [TALARICH    400.00] 504133 [URAVAKONDA  400.00]  1        1           0
 504133 [URAVAKONDA  400.00] 514023 [MAHABUB4    400.00]  2        1           0
 524004 [DAVAN4      400.00] 524044 [HIRY        400.00]  2        1           0
 524009 [HASSAN4     400.00] 524097 [CNHALLI     400.00]  1        1           0
 524044 [HIRY        400.00] 524082 [BELLARY     400.00]  2        1           0
 524050 [JAGALUR4    400.00] 524086 [BELLARY-POOL400.00]  3        1           0
 524098 [MADHUGI4    400.00] 544113 [DHARMAPURI  400.00]  2        1           0
 544094 [ANIKADAV    400.00] 544097 [RASIPALAYAM 400.00]  1        1           0
```

Table : 7

Sl. No	Transmission lines taken out of service
1	CUDDAPAH - NPKUNTA 400kV Ckt.
2	PANYAM – KONDAPURAM 400kV Ckt.
3	HINDUPUR - NPKUNTA 400kV Ckt.
4	TALARICH - KONDAPURAM 400kV Ckt.
5	TALARICH – URAVAKONDA 400kV Ckt.
6	URAVAKONDA - MAHABUBNAGAR 400kV Ckt.

Sl. No	Transmission lines taken out of service
7	DAVANGIRI – HIRIYUR 400kV Ckt.
8	HASSAN - CNHALLI 400kV Ckt.
9	HIRIYUR - BELLARY 400kV Ckt.
10	JAGALUR - BELLARY-POOL 400kV Ckt.
11	MADHUGI - DHARMAPURI 400kV Ckt.
12	ANIKADAV - RASIPALAYAM 400kV Ckt.

```
BUSES WITH VOLTAGE GREATER THAN 1.0500:

   BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)      BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)
 504042 HINDUPUR    400.00    5 1.0547 421.88    524010 MYSORE4     400.00    5 1.0557 422.28
 524050 JAGALUR4    400.00    5 1.0673 426.94    524097 CNHALLI     400.00    5 1.0690 427.61
 534049 KASRGODE4   400.00    5 1.0511 420.45    534857 WAYANAD4    400.00    5 1.0564 422.56
```

Table :8

Sl. No	BUS Name	ISTS/STU	Voltage level(kV)	Voltage Observed (kV)
1	CNHALLI	KAR	400	427
2	JAGALUR	KAR	400	427
3	MYSORE	ISTS	400	422
4	WAYANAD	KER	400	422
5	HINDUPUR	AP	400	422
6	KASRGODE	KER	400	420

Case-2 : Further, to control the high voltages on the above buses mentioned in table-8, bus reactors in addition to the bus reactors in table-5 are also required.

Table :9

Sl. No.	Bus Name	Voltage (in kV)	ISTS / STATE	Existing / UC BUS Reactor (MVAr)	Proposed bus reactor (MVAr)
1	HINDPUR	400	AP	80	125
2	CNHALLI	400	KAR	-	125
3	JAGALUR	400	KAR	-	125

With these, the system study results shows that all the buses in the Southern Region grid are below 420kV under the off-peak conditions, however following buses are observed with voltages above 412kV which are also to be considered high voltage in accordance with the Transmission Planning Criteria under the planning stage .

```
BUSES WITH VOLTAGE GREATER THAN 1.0500:

   BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)      BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)

                                          * NONE *
BUSES WITH VOLTAGE GREATER THAN 1.0300:

   BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)      BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)
 504007 CUDDAPAH    400.00    5 1.0306 412.25    504008 GOOTY       400.00    5 1.0315 412.60
 504042 HINDUPUR    400.00    5 1.0359 414.37    504050 NPKUNTA     400.00    5 1.0331 413.26
 504057 MUDDANUR    400.00    5 1.0300 412.01    504087 URAVAKONDA2 400.00    5 1.0323 412.91
 504133 URAVAKONDA  400.00    5 1.0338 413.52    504204 KALIKIRI    400.00    5 1.0308 412.33
 514068 RAIDURG     400.00    5 1.0401 416.02    514069 RAIDURG DUMY400.00    5 1.0394 415.76
 514131 MANIKONDA   400.00    5 1.0332 413.28    514164 VATTEM      400.00    5 1.0301 412.03
 514173 UDDANDAPUR  400.00    5 1.0330 413.19    524007 NELMANG4    400.00    5 1.0322 412.89
 524009 HASSAN4     400.00    5 1.0350 413.99    524010 MYSORE4     400.00    5 1.0434 417.35
 524011 KOLAR       400.00    5 1.0307 412.27    524044 HIRY        400.00    5 1.0406 416.23
 524048 DHONI4      400.00    5 1.0332 413.30    524050 JAGALUR4    400.00    5 1.0438 417.50
 524087 TUMKUR SP   400.00    5 1.0379 415.17    524097 CNHALLI     400.00    5 1.0487 419.47
 524098 MADHUGI4    400.00    5 1.0342 413.67    524169 PEENYA4     400.00    5 1.0306 412.23
 534003 KOZIKODE4   400.00    5 1.0354 414.17    534049 KASRGODE4   400.00    5 1.0414 416.55
 534857 WAYANAD4    400.00    5 1.0473 418.92    544005 MADURAI4    400.00    5 1.0332 413.29
 544006 UDUMALPET   400.00    5 1.0337 413.49    544009 THENAMPATTY 400.00    5 1.0335 413.41
 544013 PUGALUR4    400.00    5 1.0408 416.34    544014 ARASUR4     400.00    5 1.0360 414.41
 544016 PUGALUR-NEW 400.00    5 1.0405 416.19    544017 KARAIKUDI   400.00    5 1.0411 416.46
 544027 KAYATHAR4   400.00    5 1.0305 412.18    544063 VELALAVIDU  400.00    5 1.0438 417.53
 544072 UDANGUDI4   400.00    5 1.0312 412.47    544092 KARMADAI    400.00    5 1.0334 413.37
 544093 TAPPAKUNDU  400.00    5 1.0384 415.36    544094 ANIKADAV    400.00    5 1.0358 414.32
 544097 RASIPALAYAM 400.00    5 1.0346 413.84    544113 DHARMAPURI  400.00    5 1.0312 412.49
 544122 EDAYARPLYAM 400.00    5 1.0318 412.71    544128 COIMBATORE  400.00    5 1.0337 413.47
 544132 KAMUTHI4    400.00    5 1.0369 414.77    544150 KOLAPALUR4  400.00    5 1.0320 412.80
 544166 SAMUGARANGAP400.00    5 1.0319 412.77    544999 VIRUDHNAGAR 400.00    5 1.0385 415.40
 548999 VIRUDHNAGAR 765.00    5 1.0363 792.80
```

Table :10

Sl. No.	Bus Name	ISTS / STU	Voltage level(kV)	Observed Voltage (kV)
1	VIRUDHNAGAR	TN	765	793
2	CNHALLI	KAR	400	419
3	WAYANAD	KER	400	419
4	VELALAVIDU	TN	400	418
5	JAGALUR	KAR	400	418
6	MYSORE	ISTS	400	417
7	KASRGODE	KER	400	417
8	KARAIKUDI	ISTS	400	416
9	PUGALUR	ISTS	400	416
10	HIRIYUR	ISTS	400	416
11	PUGALUR-NEW	ISTS	400	416
12	RAIDURG	TEL	400	416
13	VIRUDHNAGAR	TN	400	415
14	TAPPAKUNDU	TN	400	415
15	TUMKUR SP	ISTS	400	415
16	KAMUTHI	TN	400	415
17	ARASUR4	ISTS	400	414
18	HINDUPUR	AP	400	414

Sl. No.	Bus Name	ISTS / STU	Voltage level(kV)	Observed Voltage (kV)
19	ANIKADAV	TN	400	414
20	KOZIKODE	ISTS	400	414
21	HASSAN	ISTS	400	414
22	RASIPALAYAM	TN	400	414
23	MADHUGI	ISTS	400	414
24	URAVAKONDA	AP	400	414
25	UDUMALPET	ISTS	400	413
26	COIMBATORE	TN	400	413
27	THENAMPATTY	TN	400	413
28	KARMADAI	TN	400	413
29	DHONI	KAR	400	413
30	MADURAI	ISTS	400	413
31	MANIKONDA	TEL	400	413
32	NPKUNTA	ISTS	400	413
33	UDDANDAPUR	TEL	400	413
34	URAVAKONDA2	AP	400	413
35	NELMANG	KAR	400	413
36	KOLAPALUR	TN	400	413
37	SAMUGARANGAP	TN	400	413
38	EDAYARPLYAM	TN	400	413
39	GOOTY	ISTS	400	413
40	DHARMAPURI	ISTS	400	412
41	UDANGUDI	TN	400	412
42	KALIKIRI	AP	400	412
43	KOLAR	ISTS	400	412
44	CUDDAPAH	ISTS	400	412
45	PEENYA	KAR	400	412
46	KAYATHAR	TN	400	412
47	VATTEM	TEL	400	412
48	MUDDANUR	AP	400	412

Case-3 : Further to control the high voltage on buses mentioned in table-10, following additional bus reactors, are required .

Table : 11

Sl. No.	Bus Name	Voltage (in kV)	ISTS / STATE	Existing / UC BUS Reactor (MVAr)	Proposed bus reactor (MVAr)
1	CNHALLI	400	KAR	-	125
2	WAYANAD	400	KER	-	125
3	VELALIVIDU	400	TN	-	125
4	RAIDURG	400	TEL	-	125

From the system studies, followings buses are still experiencing voltage more than 412kV but are less than 420kV

```
BUSES WITH VOLTAGE GREATER THAN 1.0300:

   BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)      BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)
 504042 HINDUPUR    400.00    5 1.0307 412.27    524010 MYSORE4     400.00    5 1.0306 412.22
 524044 HIRY        400.00    5 1.0333 413.32    524050 JAGALUR4    400.00    5 1.0331 413.22
 524087 TUMKUR SP   400.00    5 1.0310 412.40    524097 CNHALLI     400.00    5 1.0331 413.23
 544013 PUGALUR4    400.00    5 1.0313 412.53    544016 PUGALUR-NEW 400.00    5 1.0312 412.49
```

Table :12

Sl. No	Bus Name	ISTS /STU	Voltage level (kV)	Observed Voltage (kV)
1	HIRIYUR	ISTS	400	413
2	CNHALLI	KAR	400	413
3	JAGALUR	KAR	400	412
4	PUGALUR	ISTS	400	412
5	PUGALUR NEW	ISTS	400	412
6	TUMKUR SP	ISTS	400	412
7	MYSORE	ISTS	400	412
8	HINDPUR	AP	400	412

Case-4 : Further to control the voltage on these buses mentioned in table-12, followings additional bus reactors are required

Table : 13

Sl. No.	Bus Name	Voltage (in kV)	ISTS / STATE	Existing / UC BUS Reactor (MVAr)	Proposed bus reactor (MVAr)
1	JAGALUR	400	KAR	-	125
2	HIRIYUR	400	ISTS	-	125

With above reactors, the system studies shows that followings buses are still having voltage more than 412kV but are less than 420kV

```
BUSES WITH VOLTAGE GREATER THAN 1.0300:

BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)      BUS# X-- NAME --X BASKV AREA  V(PU)  V(KV)
 544013 PUGALUR4    400.00    5 1.0307 412.29    544016 PUGALUR-NEW 400.00    5 1.0305 412.21
```

Sl. No	Bus Name	ISTS /STU	Voltage level(kV)	Observed Voltage (kV)
1	PUGALUR	ISTS	400	412
2	PUGALUR NEW	ISTS	400	412

The bus reactors are still required on the Pugalur existing substations and Pugalur HVDC Station to control the voltages. Accordingly, 1x125 Mvar at Pugalur existing and 2x125 Mvar Pugalur HVDC Station is required.

4.0 Summary

In view of the system study results under 2021-22 time frame following bus reactor at the substations are required to keep the bus voltages under control under off-peak conditions. Accordingly, the installation of the bus reactors are proposed with the following details.

Sl. No.	Bus Name	Voltage (in kV)	ISTS / STATE	Existing / UC BUS Reactor (MVAr)	Bus Reactor proposed (MVAr)
1	HOSUR	400	ISTS	63	125
2	MADHUGI	400	ISTS	63	125
3	DHARAMPURI	400	ISTS	-	125
4	HIRIYUR	400	ISTS	-	125
5	PUGALUR	400	ISTS	-	125
6	PUGALUR HVDC STN	400	ISTS	-	2x125
7	RACHAGUNNERI	400	AP	-	125
8	SURYPET	400	TEL	-	125
9	RAIDURG	400	TEL	-	2x125
10	KAMALAPURAM	400	TEL	-	125
11	NARSAPUR	400	TEL	-	125
12	MAHESHWARAM-TS	400	TEL	-	125
13	TIPPAPUR	400	TEL	-	125
14	MANIKONDA	400	TEL	-	125
15	JANAGAON	400	TEL	-	125
16	CHOUTTUPPAL	400	TEL	-	125
17	YELLAMPALLI	400	TEL	-	125
18	YERAMARUS	400	KAR	-	125
19	BELLARY PS	400	KAR	-	2x125
20	HINDPUR	400	AP	80	125
21	CNHALLI	400	KAR	-	2x125
22	JAGALUR	400	KAR	-	2x125
23	WAYANAD	400	KER	-	125
24	VELALIVIDU	400	TN	-	125

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Annexure-I

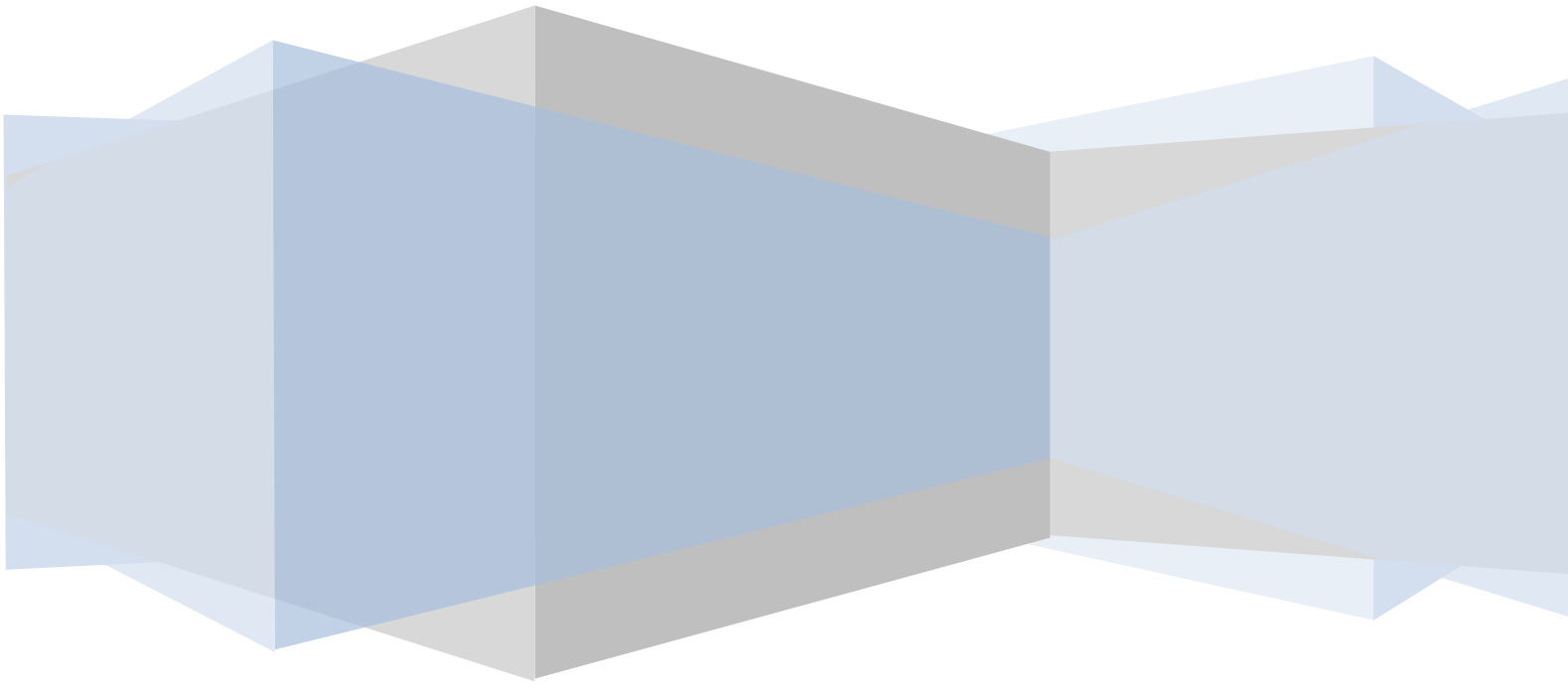
Power System Operation Corporation Limited

Operational Feedback on Transmission Constraints

January 2018

National Load Despatch Centre

New Delhi



S. No	Nodes	Season/ Antecedent Conditions	Description of the constraints	Figure/ table no.	Has the constraint occurred in earlier quarter?
5	400kV Palakkad SS	During peak load condition	Voltages are low during the peak load condition	**Figure-C5**	Yes
6	400kV Cochin SS	During peak load condition	Voltages are low during the peak load condition	**Figure-C6**	Yes
7	400kV Trivendrum SS	During peak load condition	Voltages are low during the peak load condition	**Figure-C7**	Yes

5.1.4 Nodes Experiencing High Voltage

S. No	Nodes	Season/ Antecedent Conditions	Description of the constraints	Figure/ table no.	Has the constraint occurred in earlier quarter?
1	400kV Gooty SS	Monsoon period and off peak period	Voltages remain very high most of the time	**Figure-D1**	Yes
2	400kV Nunna SS	Whole Year	Voltages remain very high most of the time	**Figure-D2**	Yes
3	400kV Sattenapally	Whole Year	Voltages remain very high most of the time	**Figure-D3**	Yes
4	400kV Kurnool SS	Monsoon period and off peak period	Voltages remain very high most of the time	**Figure-D4**	Yes

S. No	Nodes	Season/ Antecedent Conditions	Description of the constraints	Figure/ table no.	Has the constraint occurred in earlier quarter?
5	400kV Jamalamadugu SS	Whole year	Voltages remain very high most of the time	**Figure-D5**	Yes
6	400kV Ghani SS	Whole year	Voltages remain very high most of the time	**Figure-D6**	Yes
7	400kV K V Kota SS	Whole year	Voltages remain very high most of the time	**Figure-D7**	Yes
8	400kV Urvakonda SS	Whole year	Voltages remain very high most of the time	**Figure-D8**	Yes
9	400kV Dindi SS	Last quarter (From Apr-till now)	Voltages remain very high most of the time	**Figure-D9**	Yes
10	400kV Suryapet SS	Last quarter (From Apr-till now)	Voltages remain very high most of the time	**Figure-D10**	Yes
11	400kV Malkaram SS	During off peak	Voltages remain very high most of the time	**Figure-D11**	Yes
12	400kV Veltoor	Monsoon period and off peak period	Voltages remain very high most of the time	**Figure-D12**	Yes
13	400kV Mamidipally SS	Whole year	Voltages remain very high most of the time	**Figure-D13**	Yes
14	400kV Hyderabad SS	Monsoon period and off peak period	Voltages remain very high most of the time	**Figure-D14**	Yes
15	400kV Srisailam LB SS	Whole year	Voltages remain very high most of the time	**Figure-D15**	Yes
16	400kV Kaiga SS	During off peak	Voltages remain very high most of the time	**Figure-D16**	Yes

S. No	Nodes	Season/ Antecedent Conditions	Description of the constraints	Figure/ table no.	Has the constraint occurred in earlier quarter?
17	400kV Hassan SS	During off peak	Voltages remain very high most of the time	**Figure-D17**	Yes
18	400kV Talaguppa SS	Whole Year	During Low generation period and off-peak period 400kV Narendra Voltage are High.	**Figure-D18**	Yes
19	400kV Karaikudi SS	During off peak	During Low wind condition and off-peak condition Voltages are very High	**Figure-D19**	Yes
20	400kV Thiruvallam SS	During off peak	Voltages remain very high most of the time	**Figure-D20**	Yes
21	400kV Udumalpet SS	During off peak	During Low wind condition and off-peak condition Voltages are very High	**Figure-D21**	Yes
22	765kV Kurnool SS	Whole Year	Voltages remain very high most of the time	**Figure-D22**	Yes
23	765kV Srikakulam SS	Whole Year	Voltages remain very high most of the time	**Figure-D23**	Yes
24	765kV Raichur SS	Whole Year	Voltages remain very high most of the time	**Figure-D24**	Yes
25	765kV Thiruvallam SS	Whole Year	Voltages remain very high most of the time	**Figure-D25**	Yes

Section 2: Action taken in real-time to mitigate constraint

5.2.1 Lines opened on High Voltage

A list of Lines that were physically opened by Real-time operators to control overvoltages in the Grid is shown below:

S. No.	Name of Elements	Owner Name	Total No. of Outages	Total No. of Hours of Outage
1	400 kV KV KOTA-SURYAPET-2	TGTRANSCO	92	8.5
2	400 KV MAHABOOBNAGAR - URAVAKONDA - 2	APTRANSCO	89	22.1
3	400 KV MAHABOOBNAGAR - URAVAKONDA - 1	APTRANSCO	83	7.3
4	400 kV Vijayawada-Lanco 1	LANCO ST2	62	13.0
5	765 KV RAICHUR - KURNOOL - 2	POWERGRID	50	137.7
6	400 kV PUGALUR - KARAIKUDI-2	POWERGRID	48	38.8
7	400 kV SRISAILAM - DINDI -1	TGTRANSCO	45	20.2
8	400kV SURYAPET -MALKARAM	TGTRANSCO	42	38.4
9	400 kV VIJAYAWADA - KHAMMAM	POWERGRID	39	19.8
10	400 KV KUDGI PG - TUMKUR - 2	POWERGRID	38	68.9
11	400 KV URAVAKONDA - JAMMALAMADUGU - 2	APTRANSCO	37	183.9
12	400 kV BPS - TUMKUR - 2	KPTCL	36	4.1
13	400 kV MYSORE - HASAN 1	POWERGRID	36	110.0
14	400 kV HASSAN - NEELAMANGALA 1	POWERGRID	35	8.2
15	400 Kv HASSAN - UPCL 1	KPTCL	35	84.3
16	400 KV KUDGI PG - TUMKUR - 1	POWERGRID	33	79.6
17	400 kV PUGALUR - kARAIKUDI-1	POWERGRID	28	24.7
18	400kV KUDGI-NARENDRA-1	POWERGRID	28	16.6
19	765 KV NIZAMABAD - MAHESHWARAM - 2	POWERGRID	28	130.8
20	400kV VTPS -MALKARAM	APTRANSCO	25	14.6
21	765 KV KURNOOL - NPS 2	POWERGRID	25	21.9
22	765 KV KURNOOL - NPS 1	POWERGRID	24	23.7
23	400 kV KHAMMAM - KTPS 2	TGTRANSCO	20	12.7
24	400 Kv KUDAMKULAM - MADURAI	POWERGRID	19	31.2

S. No.	Name of Elements	Owner Name	Total No. of Outages	Total No. of Hours of Outage
25	400 kV GUTTUR - NARENDRA 2	POWERGRID	18	52.1
26	400 KV GOOTY - TUMKUR - 1	POWERGRID	17	50.8
27	400 kV Khammam-N'Sagar-2	POWERGRID	17	14.6
28	400 kV GUTTUR - NARENDRA 1	POWERGRID	16	48.0
29	400 KV DHARMAPURI - TUTICORN PS - 1	POWERGRID	15	23.7
30	400 kV KARAIKUDY - MADURAI	POWERGRID	15	25.4
31	400 kV KV KOTA-SURYAPET-1	INTER STATE	14	1.6
32	765 KV NIZAMABAD - MAHESHWARAM - 1	POWERGRID	14	43.6
33	400 KV JAMMALAMADUGU - KURNOOL - 2	APTRANSCO	13	10.1
34	400 Kv SATTENAPALLI - SRISAILAM 1	APTRANSCO	12	9.5
35	400 kV MYSORE - HASAN 2	POWERGRID	11	48.9
36	400 kV TIRUNELVELI - KUDAMKULAM 4	POWERGRID	11	43.0
37	400KV VEMAGIRI - SATTENAPALLY	APTRANSCO	11	15.0
38	400 kV VEMAGIRI - SIMHADRI 1	POWERGRID	10	12.6
39	400 kV TIRUNELVELI - KUDAMKULAM 2	POWERGRID	9	26.7
40	400 kV PUGALUR - KALAIVANTHAPATTU 1	POWERGRID	8	16.3
41	400 Kv KOLAR - TVLLM	POWERGRID	7	32.6
42	400 kV MAMIDIPALLY - DINDI- I	TGTRANSCO	7	10.0
43	400 KV JAMMALAMADUGU - KURNOOL - 1	APTRANSCO	6	9.3
44	400 kV NELAMANGALA - MYSORE 1	POWERGRID	6	34.6
45	400 Kv PUGALUR - KARAIKUDI 1	TNEB	6	23.3
46	400 kV TALAGUPPA - NEELAMANGALA	KPTCL	6	31.8
47	400 kV TIRUVALLUM - KALAIVANTHAPATTU 1	POWERGRID	6	16.9
48	400 kV KHAMMAM - MAMIDIPALLY 2	TGTRANSCO	4	9.2
49	400 kV TIRUVALLUM - KALAIVANTHAPATTU 2	POWERGRID	4	11.7
50	400 kV TRICHY - KARAIKUDY	POWERGRID	4	24.6
51	400 KV GOOTY - TUMKUR - 2	POWERGRID	3	11.8
52	400 Kv NELAMANGALA - BIDADI 1	POWERGRID	3	19.7
53	765kV SRKLM - VMGRI - 2	POWERGRID	3	24.6

S. No.	Name of Elements	Owner Name	Total No. of Outages	Total No. of Hours of Outage
54	400 Kv COASTAL - TTRNPS	POWERGRID	2	13.3
55	400 kV MADURAI - PUGALUR 2	POWERGRID	2	11.7
56	400 Kv MADURAI - TTRNPS-1	POWERGRID	2	13.2
57	400 Kv NTPL - TTRNPS	POWERGRID	2	13.5
58	400kV MAHESHWARAM - NARNOOR	POWERGRID	2	9.2
59	400 kV KHAMMAM - N'SAGAR	POWERGRID	1	15.7
60	400 KV KUDGI - NARENDRA - 2	POWERGRID	1	6.5
61	400 kV TIRUNELVELI - KUDAMKULAM 3	POWERGRID	1	8.5
62	400 KV TUMKUR-BIDADI-2	POWERGRID	1	5.3
63	400 kV UDUMALPET - TIRUNELVELI 2	POWERGRID	1	16.2
64	400 KV URAVAKONDA - JAMMALAMADUGU - 1	APTRANSCO	1	0.8

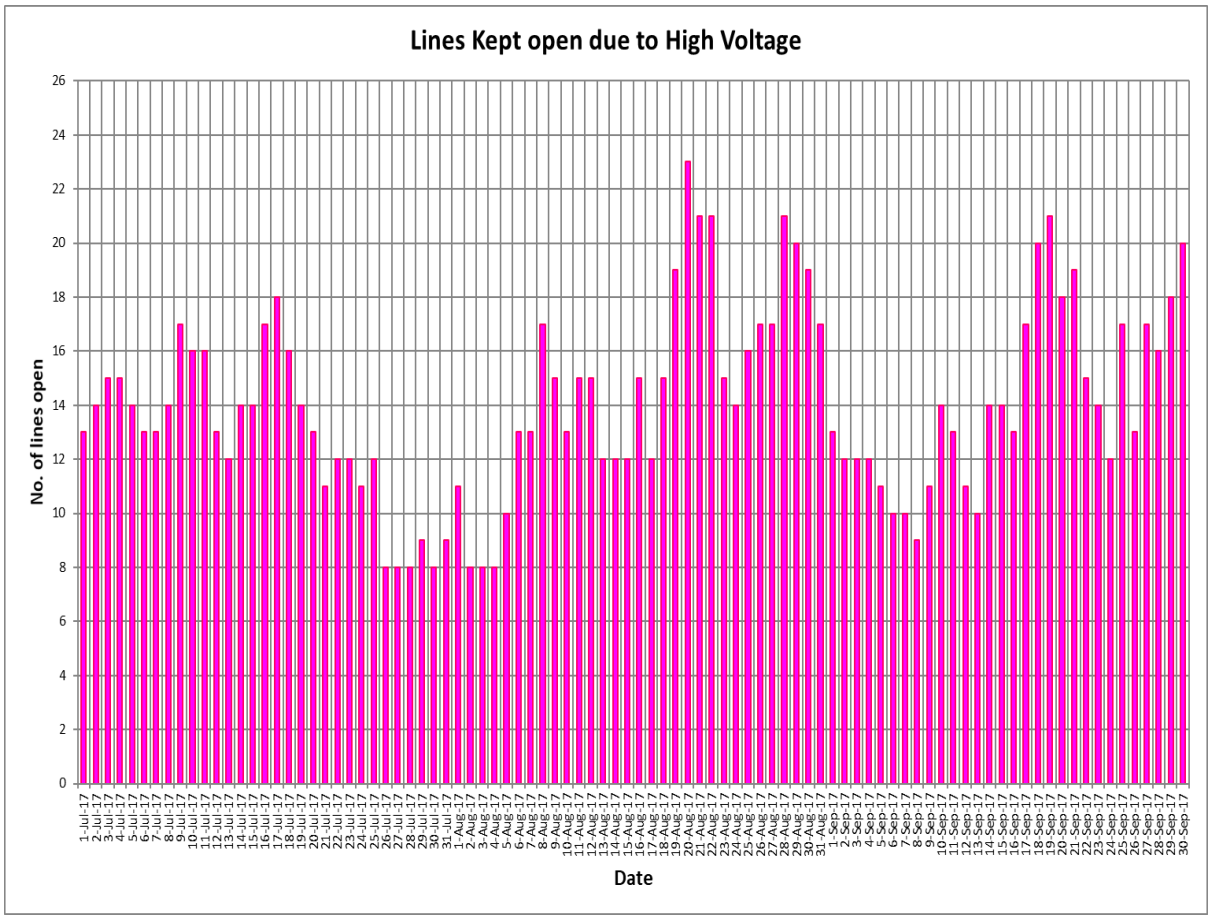


Fig. 1: Lines opened on high Voltage