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

No. 51/4/(SR-WR)/SP&PA-2015/ 845 - 867 **Date: 07-Apr-2015**

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

Sir,

The **Joint Meeting** of the Standing Committee on Power System Planning of Southern Region and Western Region is to be held on 20 April, 2015, at NRPC Katwaria Sarai, New Delhi. The meeting will commence at 11.00 AM.

The agenda is available at CEA's website (www.cea.nic.in).

Kindly make it convenient to attend the meeting.

Yours faithfully,

07/04/2015

(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*

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**

Agenda Note for Joint Meeting of Standing Committee on Power System Planning in Southern Region and Western Region

Date:15th April, 2015, Time: 03.00 PM

Venue: at NRPC Katwaria Sarai, New Delhi

1.0 Modification in Raigarh-Pugalur- Kerala 6000 MW HVDC System

1.1 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)". The proposed modified scope is 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)

1.2 The scope of this scheme as agreed earlier in the 37th meeting of the SCPSPSR, held on 31-July-2014 is given below:

(i) Raigarh(HVDC Stn) – Pugalur (HVDC Stn) +800 kV 6000 MW HVDC bipole

(ii) Establishment of Raigarh +800 kV HVDC Stn with 6000 MW HVDC terminals

(iii) Establishment of Pugalur HVDC Stn with 6000 MW HVDC terminals (or Alternatively: (i) with Pugalur HVDC Stn with 4000 MW terminal, and (ii) Madakkathara, in Kerala HVDC Stn with 2000 MW terminal and inter-connection with existing 400kV AC S/S at Madakkathara)

(iv) Raigarh HVDC Station – Raigarh(Existing) 400kV (quad) 2xD/c lines (or with bay extension)

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

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

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

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

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

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

1.3 MoP vide their letter No 15/9/2013 dated 10-Dec-2014 allocated this scheme for implementation by PGCIL under compressed time schedule through regulated tariff mechanism. The scope of the scheme as per this order is given below:

(i) ± 800 kV Raigarh(HVDC Stn) – Pugalur (HVDC Stn) – Madakkathara (HVDC Stn) HVDC Bipole line.

(ii) Establishment of Raigarh HVDC Stn with 6000 MW HVDC terminals

(iii) Establishment of Pugalur HVDC Stn with 4000 MW terminal, and Madakkathara, in Kerala HVDC Stn with 2000 MW terminal and inter-connection with existing 400kV AC S/S at Madakkathara.

(iv) Raigarh HVDC Station – Raigarh(Existing) 400kV (quad) 2xD/c lines

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

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

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

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

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

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

1.4 A comparison of differences in the scope of new PGCIL proposal with earlier agreed/approved scheme is 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,	
(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.

SCPSPSR	MoP	PGCIL's New Proposal
(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

1.5 In regard to PGCIL's new proposal, following has been observed.

(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 N Trichur upto 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.

1.6 Considering above observations, PGCIL has been requested to prepare a detail note covering following aspects:

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 Pugaur-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.

1.7 Accordingly, PGCIL has furnished a note on above observation vide their letter dated 15.03.2015 (copy enclosed at **Annex I**).

1.8 The PGCIL proposal envisages using a new VSC based technology for the HVDC terminals and DC cables. As this is a new technology, only one or two such overhead lines of 1000 MW and above capacity are presently under construction in the world. Therefore, it is important to understand this technology and its implications. PGCIL might have interacted with the lead/possible vendors who may supply this technology/equipments/cable for the 2000 MW system, or the transmission companies of other countries who are in process of implementing such a system. In this regard PGCIL was also requested that the documentation of such interactions by PGCIL in India or abroad, in the past about two years may be provided to CEA for having better understanding of this new technology for use in this scheme or in future schemes (copy of input received by PGCIL are at **Annex II**.

1.9 It may be mentioned that thorough detailed studies and deliberations have been carried out when 400kV voltage level was introduced in India and thereafter, when 765kV AC, 1200kV AC and ± 800kV HVDC technologies were introduced in India.

1.10 This complete line of about 1800 -1900 km length would traverse through seven States i.e. Chhattisgarh, Maharashtara, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala, and out of which about 90 km would fall in the State of Kerala. Out of this 90 km in Kerala, only about 40-50 km of the stretch may face RoW problem as indicated by PGCIL. Therefore, CEA had suggested that for timely implementation of this complete line from Chhattisgarh to Kerala, with the scope as already agreed, the Government of Kerala should help in obtaining RoW for this important link in their State. CEA had also suggested that possibility of use of RoW of the Trichur-Palghat 220 kV line for building this overhead HVDC line may be explored

1.11 Members may discuss.

Annex I

पावर ग्रिड कारपोरेशन ऑफ इंडिया लिमिटेड
(भारत सरकार का उद्यम)
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
पावरग्रिड

केन्द्रीय कार्यालय : "सौदामिनी" प्लॉट सं. 2, सैक्टर-29, गुडगाँव-122 001, हरियाणा
फोन : 0124-2571700-719, फैक्स : 0124-2571760, 0124-2571761 तार 'नेटग्रिड'
Corporate Office : "Saudamini" Plot No. 2, Sector-29, Gurgaon-122 001. Haryana
Tel. : 0124-2571700-719, Fax : 0124-2571760, 0124-2571761 Gram : 'NATGRID'

संदर्भ संख्या / Ref. No.

C\CTU-Plg\S\CEA

Date:15/03/2015

Sh. Pradeep Jindal
Director (SP&PA)
Central Electricity Authority
SewaShawan, RK Puram
New Delhi - 110 066.

Subject: Implementation of HVDC Bipole link between Western Region (Raigarh, Chattisgarh) and Southern Region (Pugalur, Tamil Nadu)

Sir,

We write with reference to your letter No. 52/6/2015-SP&PA/672 dated 11/03/2015 and to the discussions during 38th Standing Committee Meeting of Southern Region held on 07/03/2015 on above subject. In this regard it may be mentioned that the subject scheme was discussed and agreed during the 37th Standing Committee Meeting of Southern Region held on 31st July, 2014 & in the 33rd meeting of the Empowered Committee on Transmission held on 30/9/2014 and to be implemented by POWERGRID under compressed time schedule through regulated Tariff mechanism. In line with the suggestion in the 37th Standing Committee Meeting, basic engineering for HVDC configuration was done and proposal with two alternatives, considering the feasibility of implementation, was submitted to CEA for discussions in 38th SCM of Southern Region Power System Planning. The alternatives broadly comprise of:

Alternative-I : ± 800 KV 6000 MW HVDC Bipole terminal at Raigarh and 4000 MW terminal at Pugalur and 2000 MW terminal at North Trichur with ±800 kV HVDC line interconnecting them.

Alternative-II : (In this alternative 6000 MW HVDC terminals at Raigarh & Pugalur are considered and to extend supply to Kerala VSC technology is proposed)

- ±800 KV 6000 MW HVDC terminal each at Raigarh & Pugalur with VSC based 2000 MW HVDC link between Pugalur and North Trichur (Kerala).

CIN : L40101DL1989GOI038121

Due to paucity of time and as some of the constituents had already left, the proposals same could not be deliberated in detail and no decision could be arrived in the 38th Standing Committee Meeting of Southern Region held on 07/03/2017. Subsequently, CEA vide their above referred letter desired certain clarifications on the proposal submitted by POWERGRID. Point wise reply to the clarifications sought by CEA is enclosed herewith. Further, as desired the details of the Technology submitted by the different suppliers is being forwarded through email for your reference.

Further considering that scheme is to be implemented in compressed time scheme by POWERGRID, accordingly tendering actions have been initiated and low cost finance has been tied up. However, to proceed further approval of constituents is required.

It is to inform that CTU, POWERGRID has called for a meeting of the constituents to discuss the LTA issues on 18/03/2015 at 11:00 am in MP Hall, POWERGRID Township, Sector 43, Gurgaon and it is requested that the Standing Committee Meeting for Southern Region for Power System Planning may also be called on the same day immediately after the LTA meeting to finalise the scope.

Thanking you

Yours faithfully,

15/3/15

(Mukesh Khanna)
AGM (CTU-Planning)

Copy to:

Sh. K K Arya
Chief Engineer (SP&PA)
Central Electricity Authority
SewaShawan, RK Puram
New Delhi - 110 066.

Point Wise Reply to Clarificationssought 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**