



## An Overview to HVDC links in India

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**ABSTRACT:** Introduction of High Voltage Direct Current (HVDC) has characteristics that render it attractive for transmission applications. The numbers of HVDC projects that have been commissioned have been on the increasing scale in the near past. Beginning with a brief historical perspective on the development of High Voltage Direct Current (HVDC) transmission systems, this paper presents an overview of the status of HVDC power plants in India today and reviews the underlying technology of HVDC systems from a design, construction, operation and maintenance points of view.

**Keywords:** HVDC links, HVDC back to back, Talcher-Kolar, Ballia-Bhiwadi, Rihand-Dadri, Chandrapur-Padge, Sasaram, Gazuwaka, Chandrapur, Vindhyanchal, Mundra-Mohindergarh.

### I. INTRODUCTION

Introduction of High Voltage Direct Current (HVDC) Transmission has revolutionized the existing power system. The biggest advantage being ease of long distance and bulk power transmission, it has facilitated the transmission of electricity from power rich states to power deficit states which coincidentally happen to be

economically poor and economically rich respectively.

#### A. HVDC Bipolar Links

There are currently five operational HVDC links in India namely Rihand-Dadri, Ballia-Bhiwadi, Chandrapur-Padge, Talcher-Kolar and Mundra-Mohindergarh. Furthermore, the Biswanath-Agra link is yet to be commissioned.



Fig. 1. Block Diagram of HVDC links.

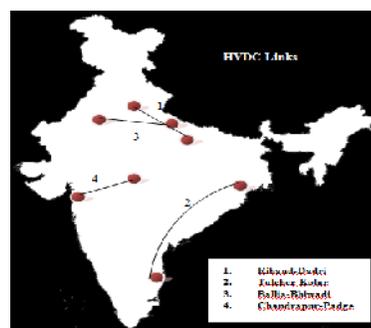


Fig. 2. HVDC Bipolar Links.

### B. Back to Back HVDC Project

Back to back stations are those where both the converters are housed in the same building and the length of the DC line is kept as short as possible.

There are currently four operational back to back projects in India namely, Vidhyanchal Back to Back, Chandrapur Back to Back, Sasaram Back to Back and Gazuwaka Back to Back.

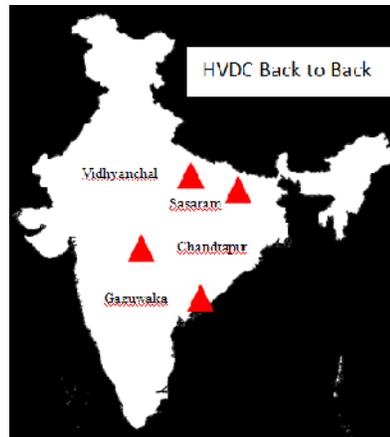


Fig. 3. HVDC Back to back Stations.

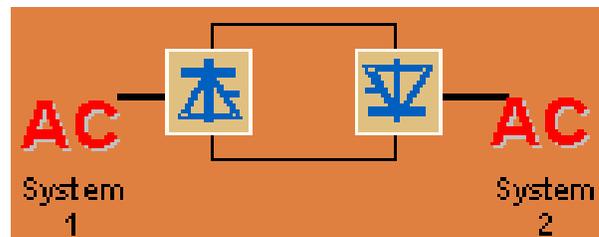


Fig. 4. Block diagram of back to back HVDC links.

## II. HVDC PROJECTS IN INDIA

### A. HVDC links in India

The first HVDC link to be commissioned in the country was Rihand-Dadri [1] in 1991 connecting Thermal power plant in Rihand, Uttar Pradesh (Eastern Part of Northern Grid) with Dadri (Western Part of Northern Grid). It has a line length of about 816 km. It was built by ABB and is currently owned by PGCIL. Each Pole has a continuous power carrying capacity of 750 MW with about 10% two hours overload and 33% five seconds overload capability. It provides the reverse power flow capability with a converter transformer rating of 6x315 MVA at Rihand Terminal and 6x305 MVA at Dadri Terminal. The next project, Chandrapur-Padge [4] HVDC link connecting Chandrapur (Central India) and Padge (Mumbai) in 1999. It transmits 1500 MW power over 752 km and helps in stabilizing the Maharashtra grid by increasing power flow on the existing 400 KV lines and minimizing total line losses.

The Talcher-Kolar [6] link connecting Talcher, (Odisha) with Kolar, (Karnataka) was completed in June 2003, designed for transmission of 2000 MW continuous rating with inherent short term overload capacity over 1369 km, making it the longest HVDC link with a converter transformer rating of 6x398 MVA. The 780 km HVDC link connecting Ballia, Uttar Pradesh and Bhiwadi [5], Rajasthan in monopolar mode in March 2010 and was furthered to operate in bipolar mode in March 2011. During inclement weather conditions it operates at 70-80% DC voltage owing to reverse power flow capability with a converter transformer rating of 8x498 MVA on both side. The Mundra-Mohindergarh link has been the most recently commissioned HVDC link connecting the Western region to the Northern region for over 986 km operating at 1500 MW. It is the first link to be commissioned by a private firm (The Adani Group).

**Table 1: List of HVDC Projects in India [1].**

S.No	Project Name	Connecting Region	Commissioned On	Power Rating	AC Voltage	DC Voltage	Mode Of Operation	No. of Poles/ Blocks	Length Of Line
1.	<b>Rihand-Dadri</b>	ER-WR	December 1991	1500 MW	400 KV	500 KV	Bipole	2	816 Km
2.	<b>Talcher-Kolar</b>	ER-SR	June 2003	2000 MW	400 KV	500 KV	Bipole	2	1369 Km
3.	<b>Ballia-Bhiwadi</b>	ER-NR	Pole1: March 2010 Pole 2: March 2011	2500 MW	400 KV	500 KV	Bipole	2	780 Km
4.	<b>Chandrapur Padge</b>	CR-WR	1999	1500 MW	400 KV	500 KV	Bipole	2	752 Km
5.	<b>Mundra-Mohindergarh</b>	WR-NR	2012	1500 MW	400 KV	500 KV	Bipole	2	986 Km
6.	<b>Bishwanath-Agra</b>	NER-ER	2015	6000 MW	400 KV	800 KV	Multi-Terminal	2	1728 Km
7.	<b>Vidhyanchal</b>	WR-NR	April 1989	2x250 MW	400 KV	70 KV	Back To Back	2	
8.	<b>Chandrapur</b>	WR-SR	December 1997	2x500 MW	400 KV	205 KV	Back To Back	2	
9.	<b>Sasaram</b>	ER-SR	September 2002	1x500 MW	400 KV	205 KV	Back To Back	2	
10.	<b>Gazuwaka</b>	ER-SR	March 2005	2x500 MW	400 KV	Block 1: 205 KV Block 2: 177 KV	Back To Back	2	

#### *B. HVDC Back to Back Projects*

The first commercial Back to back HVDC project Vindyanchal [1] (commissioned in April 1989) distributes power of 2x250 MW and connects Vindhyanchal Super Thermal Power Station to Singrauli Super Thermal Power Station. It has the advantage of bidirectional power flow. The plant achieves the load diversity of Northern and Western region of the Indian Grid using a Converter Transformer of 8x156 MVA. Chandrapur back to back [1] was the second such project, commissioned in 1993 connecting Chandrapur Thermal Power Station to Ramagundum Thermal Power Station. Coupled with the bidirectional power flow capability, it

achieves load diversity of Western and Southern Region of the Indian Grid with a Converter Transformer of 12x234 MVA. Sasaram Back to back [3] was commissioned in September 2002 delivering 500 MW having a Converter Transformer rating of 6x234 MVA. It connects Pusali (Eastern Region) to Sasaram (Eastern part of Northern grid). The Block 1 of the Gazuwaka [1] back to back HVDC Project was commissioned in 1999 and Block 2 in March 2005. It connects Jeypore to Gazuwaka Thermal Station with a converter transformer rating of 6x234 MVA for block 1 and 6x201.2 MVA for block 2. It meets the high demand of southern region using the surplus power available.

### III. HVDC PROJECT DEVELOPMENT ISSUES

There are various concerns regarding the above mentioned system which include creation of high capacity long distance transmission corridors to enable minimum cost per MW transfer, the complexity involved in realizing and extending present systems to Multi-Terminal systems, limited overload capacity of the static inverters coupled with the difficulty in installation. The high cost of installation of the plant due to the umpteen number of protection equipment required to eliminate the harmonics have been some of the issues faced in the development of existing HVDC systems. It has also been observed that implementation on DC circuit breakers is a complex task owing to the requirement of current being made zero forcefully which helps prevent arcing and contact wear and hence reliable switching. And the project so developed should also have minimal effect on the environment. Thus, to account for the ever increasing demand of power, strong, lossless transmission methods need to be developed between the generating stations and the bulk power consumers.

### IV. FUTURE PROSPECT

To facilitate the transfer of power from generating stations to bulk load centers various projects are being planned which include the introduction of 800 KV, 3000 MW upgradable to 6000 MW Multi-terminal systems<sup>[1]</sup>. The proposed site for rectifier station is in Bishwanath Chariali and Alipurduar handling 3000 MW and the Inverter station at Agra handling 6000 MW power. This system is proposed to originate from Assam and pass through West Bengal, Bihar and terminate in Uttar Pradesh with an approximate length of 1728 km. It will be the highest capacity HVDC project of the world considering the continuous 33% overload feature. Each pole of the multi-terminal shall be designed for 2000 MW which are the highest capacity poles in the world. The Earth Electrode shall be designed for 5000 Ampere DC continuous current which

shall be the first of its kind in the world. This project is expected to be commissioned by 2015. It also includes the extension of the Mundra-Mohindergarh HVDC link currently operating at 1500 MW to its full installed capacity of 2500 MW. The proposed HVDC link project by PGCIL between India and Sri Lanka connecting Madurai (Southern India) and Anuradhapura (Central Sri Lanka) would be of 285km length including 50km of submarine cables. The project would take the final form in two phases, first would enable the transfer of 500 MW and 1000 MW, the target capacity in the second phase in near future. Such a connection would enable the two countries to sell excess energy thus saving resources. Another proposed HVDC link connecting Behrampur (India) with Bheramara (Bangladesh) is announced by Power Grid Corporation of India Limited (PGCIL) and Bangladesh Power Development Board (BPDB). The line will have initial transfer capacity of 500 MW, which will later be increased to 1000 MW. The 125 Km line will cover 40 km of its length in Bangladesh and rest in India. Bangladesh is supposed to start selling 250 MW Power by the end of 2012. Further, research has been going on in the field of implementation of Adaptive Neuro-Fuzzy logic for the fault identification of the present HVDC systems. The ANFIS system has an advantage over normal controllers in the fact that they do not require mathematical modeling i.e. absolute data to work. In the present installations, 70% of the data would be provided to the ANFIS system and the rest 30% would be left for testing and validation. The circuit shall be enriched with a conventional PI controller to help store the results. Another advantage of using this technique would be in terms of the delay angle. Earlier in fault identification systems, the entire working of the circuit depended on the correct choice of the delay angle which had an upper limit usually of 60°. However, no such limitation exists in this system.

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