Taming the HVDC Dragon

It is always interesting and encouraging to look beyond what is seen. There can be no better inspiration and motivation then delving deep into the construction of engineering marvels and mega structures especially from the point of view of the team efforts put in behind it. Here is a behind-the-scene account of the making of the HVDC Transmission System constructed by APL in between Mundra and Mohindergarh that Adani Transmission Limited is proud of.

The Adani Group with an objective to create a presence across power business forayed into power generation and then to power transmission. This foray in transmission sector was a bold step but it helped aggressive bidding of the power supply tenders, being cost effective and independent.

The Mundra - Dehgam Transmission system built by Adani Transmission Limited connected to the Central Transmission Utility (CTU) could cater only upto a maximum of 1200 MW of evacuation. Moreover, the surplus power handling capacity at Dehgam substation of CTU and further delivering to Haryana was not available. This called for system strengthening, building of new lines, reducing transmission losses and overcoming space limitations in existing substations and more.

Therefore only option was viable which was to make our own transmission system, a sort of a power highway up to Haryana for which many options were examined. The system decision was based on the fulfilment of the following criteria:

i) **Minimum Losses in Transmission:** Transmitting electricity at high voltage reduces the fraction of energy lost to resistance depending on the conductors, the current flowing and the length of the line. Though this sounds less in terms of percentage i.e. 3-4% but is very high when calculated from economic perspective.

ii) **Minimum 'Right of way (ROW)' for Line corridors:** Right of way is a term first used to describe the right to access a route regardless of land ownership or any other legality. With increase in transmission voltage, the requirement of land for tower footing increased quite substantially. To save environment, time and avoid disputes for obtaining ROW the land area requirement should be less.

iii) **High reliability under system/ grid disturbances:** Reliability of a system is measured by the number of forced outages per year. Forced outage is the shutdown of a generating unit, transmission line, or other facility for emergency reasons or a condition in which the generating equipment is unavailable for load due to unanticipated breakdown.

iv) **High availability to take care of contingencies:** Availability of a system is measured by the period in which transmission element is available to transmit up to its full capacity.

v) **Proven Technology**

vi) **Possibility to control the Power flow**

vii) **Most optimum cost of the system to control investment**

HVDC – The Perfect Fit

With all sorts of calculations, much techno-economic analysis and weighing all the business propositions, High Voltage Direct Current Transmission System was proving out to be the best choice. It met all the stated criteria closely. Furthermore during the discussions with Haryana, it came out that Haryana was constructing a 400 kV substation at Mohindergarh and this station will be connected to various load centers in Haryana. Therefore, Mohindergarh proved to be the most appropriate point to deliver the power to Haryana under the PPA.

With this, it was decided that HVDC transmission system that shall act as a bulk power highway with capacity to transmit 2500 megawatts of power from Mundra (Gujarat) to the load centers in the National Capital Region (NCR) through an inverter station at Mohindergarh (Haryana) in a single hop of about 1000 kilometers shall be built by ATL. This was the first time any private player was getting into constructing a transmission system that no other competitor had mustered COURAGE for.

About HVDC

HVDC transmission system is a bipolar link that evacuates power from Adani power-Mundra Super Thermal Power Station of Gujarat to the Mohindergarh of Haryana state. The system consists of 2 poles of 1250 MW each, connected in bipolar configuration. It consists of a rectifier station (Mundra) to convert power from 400 KV alternating current to 500 KV direct current form, a two-pole transmission line (990 kilometer long passing through Gujarat, Rajasthan and Haryana) and an inverter station (Mohindergarh), which converts power from 500 KV Direct current form to 400 KV alternating current mode.

HVDC transmission system can transmit bulk power over long distances in a single hop over a single transmission line. Besides being economical over long distance, the technology also minimizes transmission losses, needs lesser right of way and hence minimum tree felling, less disturbance en-route to the residents and flora and fauna. HVDC just requires 52 m line corridor in comparison to 220 m line corridor required while installing conventional 400KV systems to carry same amount of power making it a clean and eco-friendly technology.

Another unique feature of HVDC transmission system is its capacity to precisely control the amount of power which should be transmitted. There are other stabilizing features also. This capability of HVDC makes it most useful during grid disturbance in preventing blackouts.

The onset of HVDC journey

It was the very first time that any private player was getting into constructing such a kind of system in India which made it certain that it was not going to be a smooth sail. There was much preparation work to be done before getting on the floor. Since, HVDC is a relatively newer technology, having sound knowledge and technical know-how for the same was essential. Getting people skilled in this area was a tedious task. It had to be difficult as there are very few sources in this field from where manpower could be supplied or taken up for this project. As a result, trainings and knowledge sharing forums were organized for all the people involved in the project. For empowering our manpower we conducted:

- Class room trainings in erection and commissioning
- Site visits of experts for assessment and addressing doubts
- Lectures and on-site training by Siemens
- Weekly knowledge-sharing sessions
- Visits and trainings at similar HVDC station under operation i.e. Talcher - Kolar and Balia - Bhiwani

Simultaneously, ordering of HVDC terminal station and line was done through the process of international competitive bidding by inviting bids from renowned parties. Since it was something that was not an ordinary job, each contractor was meticulously evaluated and allocated for the operations. The journey towards building the HVDC system started. However, the journey had never been very smooth;we never expected it to be. Each tower foundation was a project in itself. Starting from political interferences to severe ROW issues, there were many challenges involved right from the start of the project. A dearth of experienced and skilled manpower and contractors kept deterring smooth operations. Delays in approval for licenses and other legalities pertaining to railway crossing, power line crossing etc were becoming huge hindrances. Delays in

approvals from forest authorities were also hindering the progress. To top it all, the weather across the HVDC landscape was very tricky making it extremely difficult for people to work day and night.

When weather turns against you:

Story 1: *The journey had seen many ups and downs as we came across many interesting situations. Constructing HVDC transmission line through creek area of Gujarat covering around 15kM area full of water bodies of Arabian Sea was certainly a difficult task. Creek area is low lying in nature and hence remains water logged for almost 10 months in a year. Even, the normal water levels are above 1.20 meters. Adding woes to the worries were unprecedented rains in this area. The stringing work was becoming nearly impossible as most of the area was waterlogged up to chest height. Amid marshy, slushy and muddy cart tracks; men and materials were transported by tractors and excavators. Also during summers, because of frequent sand storms the work was becoming even more difficult. Even under such adverse situation, our transmission team refused to give up and completed entire stringing work.*

When you march into a restricted piece of land:

While construction of HVDC transmission line there was a patch that passed through Sikar district of Rajasthan. In this patch, APL was successfully proceeding in its work. Foundation work had been completed at about 24 sites in this region and tower erection was done at 6 sites in this region. Suddenly, the work progress was objected by a lobby of mining agencies because it was passing through many mining areas that were not demarcated anywhere on the paper or maps. After many trials in courts and many legal cases, APL settled to stop the work. Eventually, the entire work in this area was stopped and the erected towers along with other foundation work were bulldozed. This caused sheer wastage of time and resources. However, our top management compensated this reduced working period by reinforcing additional resources to cope with the scheduled time frame. There were special cranes brought in to speed up the process of tower erection at other sites.

We owe our success to our committed teams. However, it was just not about facing the weather and marching ahead with courage and commitment but there was much to do with problem solving in a creative manner. Some problems demanded an out-of-box and innovative approach to deal with. Be it pre-engineered solutions for constructing valve hall or be it special cranes for erecting the transmission towers in less time. Every possible innovation and resource mobilization was done to make things possible and to deliver results within the set time frame.

When only innovation can save time:

The HVDC substation comprises a structure called valve hall. This valve hall holds Thyristor valves which are used to switch power on the scale of megawatts. This valve hall is a huge structure (as big as a basketball court) which needs to be kept air tight and a little pressurized to avoid dust entry. However, the conventional valve halls are huge structure and take considerable time to construct which was not possible with this fast track project. At this, our engineers explored various possibilities in consultation with suppliers and came out with unique solution of opting for pre-fabricated steel structured valve hall which was not tried by anyone earlier. Prefabricated structure allows parallel working using modern construction tools making time management easy. This type of fabrication was new to the vendor. The vendor also took it as a challenge and finally we could complete the valve hall structure in a very short time.

Earth Electrode Station @ Kaithal

During Land acquisition at Kaithal, we came across some unique problem. One party was especially greedy and hence land acquisition was becoming nearly impossible. The party expected that we would yield to their demand as the patch of land was critical for earth electrode design. Instead of yielding to the unreasonable demand, we resorted to change the earth electrode design itself. The new design did not require the specific patch of Land. This was the first time any such design was adapted to build an earth electrode.

Despite such hindrances spread across 360 degrees, the HVDC team did not give up. There was just one goal, completing the project with all possible might, on and before time. There was no stopping and no looking back. Revisions in strategies and innovations on regular basis made this story possible. Time and again the HVDC team kept crossing milestones reaching the final destination successfully.

Success accompained by many 'Firsts' and 'Highests':

At ATL, excellence is a habit and thus success always follows our path. In laying HVDC transmission system, not only did we create another success story but also created a record with our speed of execution. The industry standard in India for completion of such a project is approximately 33 months. However the ATL Team completed the same in a record 24 months. Today, the system is operated by a team of expert HVDC professionals. During the very first year of operations, we again emerged at the top in our availability figures which gave us the titles of many firsts:

- **First private** sector Company in the country to build High Voltage Direct Current (HVDC) system spanning 990 Kms, with maximum capacity of 2500MW.
- **First project** of this nature to be completed in a record time of 24 months and create new record.
- **First** of its kind project registered in Clean Development Mechanism (CDM) -- A promise for Green Energy.
- **First** to use pre-engineered building solutions for valve hall instead of conventional concrete structures.
- First indigenously manufactured HVDC transformer of 500 MVA size.
- Largest size of transformer built.
- Second longest HVDC line across India.
- Longest Earth Electrode line

Post Construction

Commissioning and initial operation of this HVDC bipolar link provided several learning opportunities and unique experience to the maintenance staff. Despite successful testing and commissioning, desired performance levels could not be reached during initial operation owing to various technical glitches.

The reason for failures were identified, analyzed and was appropriately addressed to achieve stable operation of the Mundra-Mohindergarh HVDC Bipolar link. The investigation of these problems in the HVDC Link provided learning opportunity to the APL engineers. The experience gained in overcoming problems has instilled confidence in smooth operation of the project in the long run.

Regular maintenance practices and standards as stipulated have helped to achieve trouble-free operation of HVDC link during the peak load dispatch period. The constant power transmissions (without fluctuation) have not imposed any undue stresses on the equipment and hence no additional maintenance than stipulated is required.

The dust of Kutch:

Since the Mundra converter station is located in the coastal region, there have been repeated dc line faults especially at night hours. The porcelain insulators of the dc line are accumulated with dust and sand particles originated from salty air of the coastal and the desert of the Mundra in the morning hours. These particles used to react with moisture/fog in night hours and cause contamination flashover in the dc line resulting in repeated operation of the line fault and subsequent pole trip. Insulators in affected areas were replaced by Silicon Rubber Insulators. This gave a significant

Each part of the HVDC system has been critically examined by the Adani power HVDC team along with the original equipment manufacturer SIEMENS. At the end of the assessment, around 250 points were identified for implementation to improve the HVDC long term reliability and availability. Most of the points have been implemented whereas the rest are under implementation. To avoid any incidence of grid instability, a system protection scheme has also been implemented for fast load relief during contingency of tripping of Single pole/ Bi pole of the HVDC link. Furthermore, in near future, to prevent theft on electrode line we are going to install a special electronic monitoring system which after implementation will be the first of its kind.

With all this, HVDC link has proved to be a backbone of the Indian Transmission system. Operation of HVDC link embedded with existing HVDC system has fulfilled the commitment of enhanced grid stability, reliability and also reduction in transmission losses etc.

Gujarat's HVDC, Gurgaon's Gain:

Mundra - Mohindergarh HVDC link cater approximate 20 - 24% of total power demand of Gurgaon and other cities of Haryana state. HVDC system is operational since July 2013 with a stable availability. It is targeting availability of about 97.5% which is much better than the grid standard of 92%. Presently, we are gaining experience and expertise in this field; we may venture in to field of other FACTS and consultancy in future.

We are committed to improve further. We are committed to create more such marvels and mega structures. We are committed to once again create many records. We are committed to achieve the impossible and rewrite history. We are committed to Thinking Big, Doing Better.