December 6, 2011

Phase II HVDC Consideration Process

The three scenarios selected for Phase II analysis will be initially evaluated contemplating AC line solutions for transmission gaps identified. The process described in the Phase II Outline will be followed, starting with Task 7. Task 7 involves build-out on the three scenarios, considering 230 kV AC transmission and up. Transmission reinforcements needed to support the three scenarios will be developed and an Eastern Interconnection power flow model will be developed for each scenario. This document is not meant to compare relative benefits of AC vs. DC solutions, but rather to explain the planning process regarding technology selections.

Following this initial study, HVDC solutions may be evaluated as potential solutions based on the following guidelines:

- A cable greater than 50 km is identified to be required as part or all of a transmission line to be added. For long cables, DC may be required because of the capacitance in an AC cable which builds as a function of length, and cannot be compensated. This application includes underwater crossings. HVDC technology has been used in several Merchant Projects and at least one Regional Transmission Expansion Plan project where underwater crossings have been required.

- Power transfer between asynchronous systems is identified as a possible solution. This would require a back-to-back HVDC system, in which there is no transmission line, but the HVDC connection acts as a clutch between the two AC systems. Hydro-Quebec and ERCOT are systems that use back-to-back HVDC to connect with other systems.

- The solution identified is a long transmission line carrying a large amount of power. This is the most likely situation to arise in this study. The primary application where HVDC would be considered is a point-to-point line over 400 miles long with no taps. However, there are a number of considerations to evaluate in determining the preferred solution:

  As stated previously, HVDC systems can transmit large amounts of power over long distances with no taps very well. There are no reactive losses, and the line length is limited ultimately only by resistive losses. The HVDC power transfer can be controlled precisely, which is a desirable feature when injecting large amounts of power into a system from far away. And transmission line conductor costs are less, since only two conductors are needed, vs. three for AC lines.

  However, EHV transmission can deliver equivalent amounts of power the same distances, using switching stations every 200 miles to provide reactive compensation. The AC transmission line integrates well with the existing power system, and power can be easily tapped where needed.

HVDC systems traditionally require strong AC systems at both ends to work properly, which may pose a problem for remote generation locations.

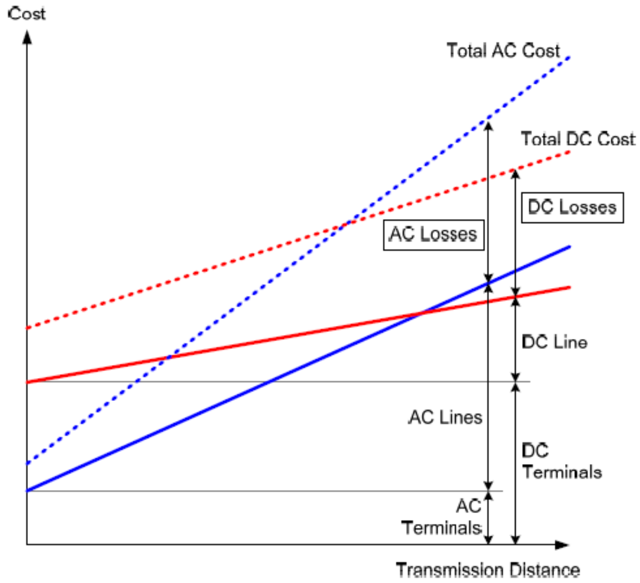
HVDC terminals are much more complex than their EHV counterparts. The converter station will include an AC switchyard plus a converter building housing the converter transformers and valves that convert from AC to DC; shunt capacitive banks for reactive compensation; AC filter banks to cancel out harmonics generated by the conversion process; and a DC switchyard.

If an HVDC solution arises for consideration, recent advances in technology provide additional flexibility. "HVDC Lite" applications using the Voltage Source Converter (self-commutated) do not require a strong AC voltage source to operate properly. Therefore, they can operate almost anywhere in the AC network. VSC based transmission can serve as the sole outlet for smaller scale wind generation using simple induction generators. VSCs do not require reactive power from the AC system and can operate at unity power factor across their entire operating range. The size limit for this technology is continually increasing, providing planners with more options.

The primary characteristic of a line in the initial AC evaluation that will cause planners to consider an HVDC application is the length of the line, and all of the cost differentials will be derived from that aspect. Of course, there could be other HVDC applications that wind farm developers might employ, but these would generally be driven by functional constraints, rather than economics.

Several facts point the planner towards AC or DC solutions. The HVDC option has a higher installation cost due to the converter stations and filtering requirements. The HVAC option will have increased costs as the length of the line increases, because of additional reactive compensation required. The cost of an HVDC transmission line is less than that of an HVAC line. The right-of-way costs are lower for HVDC lines due to smaller and fewer structures needed to transmit the same power. Finally, while HVDC line losses are higher than HVAC initially, they become relatively lower as the line gets longer. The combination of all of these factors leads to the concept of the "break-even distance", where HVDC becomes the economical choice. The figure below shows the relative costs of various items; terminals, lines, and losses. The point where the red and blue lines intersect is the break-even point.

Cost vs. Distance for HVDC and AC



Ultimately, the initial results of the Phase II evaluation will determine the need for evaluation of possible HVDC solutions.