AMERICAN ELECTRIC POWER
Transmission Facts

Q1. What are AEP transmission mileage statistics?

AEP owns the nation's largest electricity transmission system, a thirty-nine-thousand miles network operating in 11 states that includes more 765 kV extra-high-voltage (EHV) transmission lines than all other U.S. transmission systems combined. The following statistics summarize AEP's transmission line circuit miles as of December 31, 2007:

Extra-High-Voltage Transmission:		
765 kV:	2,116 Miles	
500 kV:	113 Miles	
345 kV:	5,910 Miles	
	EHV Subtotal:	8,139 Miles
High-Voltage Transmission:		
230 kV:	140 Miles	
161 kV:	282 Miles	
138 kV:	16,202 Miles	
115 kV:	66 Miles	
	HV Subtotal:	16,690 Miles
Below 100 kV:		14,230 Miles
AEP Transmission Total:		**39,059 Miles**

Source:
"American Electric Power 2008 Fact Book," 43rd EEI Financial Conference, Phoenix, AZ, November 9-12, 2008.

Q2. Why did AEP develop 765 kV transmission?

The decision to develop and implement a 765 kV transmission overlay in the 1960s (and a 345 kV overlay in the 1950s) was founded in AEP's philosophy that a strong transmission system is essential to provide efficient, reliable and flexible infrastructure to meet the ever growing demands of electricity consumers. Reliable and efficient, integrated operation requires that the resources of all power plants be available, without transmission constraints, to all parts of the system under a wide range of operating conditions and possible future scenarios. The AEP 765 kV system provides a robust backbone transmission infrastructure enabling the most economical and environmentally attractive generating resources to supply the growing demand for electricity in a broad variety of operating and market conditions.

Source:
"Development of the American Electric Power System Transmission Network: From 345 kV to 765 kV to UHV," T.J. Nagel and G.S. Vassell, CIGRE, No. 32-13, September 1974.

Q3. In general, what is the range of cost per mile for each of the following: 765 kV, 500 kV and 345 kV? (Recognizing that terrain, cost of ROW, etc. factor into it)

Typical installed costs for 765 kV, 500 kV and 345 kV transmission lines are:

Voltage Class	Cost Range/Mile*
765 kV Single Circuit	$2.6 – 4.0 Million
500 kV Single Circuit	$2.3 - 3.5 Million
345 kV Double Circuit	$1.5 - 2.5 Million
345 kV Single Circuit	$1.1 – 2.0 Million

*Average construction costs in 2008 dollars; rural terrain with rolling hills; elevations up to 4000 feet above sea level; includes siting and ROW costs; excludes station costs.

The above ranges reflect costs utilizing AEP's current standards and do not include potential design modifications or technology enhancements. These costs can be affected significantly by the following factors:

- Siting, permitting and/or environmental mitigation requirements
- Land use, population density and right-of-way land value
- Terrain and geophysical conditions and their effects on line design and construction

Q4. For 765 kV, what is the breakdown of the cost on a percentage basis into labor vs. materials? For the materials percentage, provide a further breakdown for the major components (steel, transformers, etc.)

Based on AEP's latest estimates, the following is an approximate cost breakdown for a typical 765 kV transmission line built with lattice towers:

Siting:	3%	
Right-of-Way (ROW):	10%	
Engineering & Management:	5%	
Materials:	41%	(of which 60% is structures, 30% conductors, 10% other)
Construction:	41%	

These percentages can vary for different projects and different project decisions. Most significant variations exist in the costs of ROW and materials.

For a typical 765 kV transmission station, the cost breakdown is:

Materials:	70%	(of which 50% is transformers, 20% circuit breakers, 30% other)
Labor:	30%	

Q7. Are we seeing a shortage of skilled labor and if so, how might that impact our plans?

Presently, AEP is not experiencing a shortage of skilled labor. In the future, if a significant number of projects were scheduled to go into construction simultaneously, a shortage of skilled labor could arise. Were that to happen, we would work with our contractors to develop and train a larger workforce. Since there would be some advance visibility to this issue, we would have time to respond to the need.

Q8. How does the size of the ROW compare/differ between 765 kV, 500 kV and 345 kV?

The ROW width commonly used for 765 kV, 500 kV and 345 kV lines is summarized below:

Voltage Class	ROW Width - Feet
765 kV Single Circuit	200
500 kV Single Circuit	175 - 200
345 kV Double Circuit	150
345 kV Single Circuit	150

Q9. What is the average height of 765 kV, 500 kV and 345 kV towers?

Tower heights vary with design and terrain type, and generally increase with voltage class. Note that a double-circuit 345 kV tower is actually taller than a single-circuit 765 kV design.

Voltage Class	Tower Height - Feet Hilly Terrain	Flat Terrain
765 kV Single Circuit	135	150
500 kV Single Circuit	120	135
345 kV Double Circuit	160	175
345 kV Single Circuit	110	125

Q10. Are there altitude restrictions for transmission? If so, how can they be mitigated?

High elevations above sea level are associated with reduced air density, which affects the performance of transmission lines. Specifically, as the air density declines so does its dielectric strength, resulting in greater discharge of energy from energized surfaces. This effect, known as corona, can manifest itself as audible noise and may have to be controlled to meet local regulations. Effective mitigation methods at EHV levels are to use multiple conductors in each phase and/or optimized phase bundle geometries. Reduced air density also can lower the flashover voltage threshold, necessitating more insulation or effective means for overvoltage control.

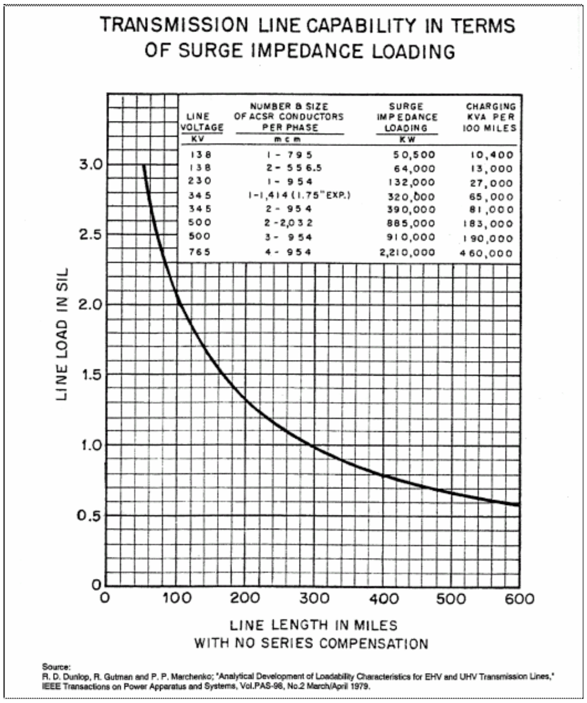
Q11. What are the load carrying capabilities of 765 kV, 500 kV and 345 kV in terms of MW and miles?

To assess the load-carrying ability, or loadability, of a transmission line, engineers commonly use the concept of Surge Impedance Loading (SIL). SIL, a loading level at which the line attains self-sufficiency in reactive power (i.e., no net reactive power into or out of the line), is a convenient "yardstick" for measuring relative loadabilities of long lines operating at different nominal voltages.

Using the SIL concept, three 500 kV or six 345 kV circuits would be required to achieve the loadability of a single 765 kV line. Specifically, a 765 kV line can reliably transmit 2200-2400 MW (i.e., 1.0 SIL) for distances up to 300 miles, whereas the similarly situated 500 kV and 345 kV lines with bundled conductors can deliver only about 900 MW and 400 MW, respectively. For short distances, these relationships can differ to some extent reflecting thermal capacities established primarily by the number/size of line conductors and station equipment ratings.

Relative loadabilities of the 765 kV, 500 kV and 345 kV lines also can be viewed in terms of transmission "reach" over which a certain amount of power, say 1500 MW, can be delivered. For a 765 kV line, this loading represents approximately 0.62 SIL which, according to the loadability characteristic (see below), can be transported reliably over a distance of up to 550 miles. By contrast, a 345 kV line carrying the same amount of power would operate at 3.8 SIL -- transportable only up to about 50 miles (assuming adequate thermal capacity); this distance would increase to about 110 miles for a double-circuit 345 kV line. The generalized line loadability characteristic incorporates the assumptions of a well-developed system at each terminal of the line and operating criteria designed to promote system reliability.

Voltage Class	Loadability (@300 Miles)	"Reach" (@1500 MW)
765 kV Single Circuit	2200 – 2400 MW	550 Miles
500 kV Single Circuit	900 MW	140 Miles
345 kV Double Circuit	800 MW	110 Miles
345 kV Single Circuit	400 MW	50 Miles



Source:
"Analytical Development of Loadability Characteristics for EHV and UHV Transmission Lines," R.D. Dunlop, R. Gutman and P.P. Marchenko, IEEE Transactions on Power Apparatus and Systems, Vol. PAS-98, No. 2, March/April 1979.

Q12. What are the standard statistics for line losses? How do line losses compare/differ between 765 kV, 500 kV and 345 kV?

An energized transmission line carrying load incurs power losses due to heating and so-called "corona" effects. Heating (or resistive) losses increase linearly with line resistance and quadratically with loading. Corona losses result from undesirable discharge of electric energy, which can be visible and/or audible especially during rain, caused by air ionization around line conductors and hardware. Corona losses increase with voltage level and elevation above sea level of the line.

The following statistics characterize EHV transmission lines operating at different voltages, in normal weather, carrying 1000 MW of power:

	LINE LOSSES - MW/100 MILES		
	Resistive	Corona*	Total
765 kV LINE @1000 MW LOAD:			
Original 4-conductor ("Rail") bundle	4.4	6.4	10.8 (1.1%)
Newer 4-conductor ("Dipper") bundle	3.3	3.7	7.0 (0.7%)
Current 6-conductor ("Tern") bundle	3.4	2.3	5.7 (0.6%)
Planned 6-trapezoidal cond. ("Kettle") bundle	3.1	2.3	5.4 (0.5%)
500 kV LINE @1000 MW LOAD:			
Typical 2-conductor bundle	11.0	1.6	12.6 (1.3%)
345 kV LINE @1000 MW LOAD:			
Typical 2-conductor bundle	41.9	0.6	42.5 (4.2%)

*Yearly average corona loss at sea level based on 20%/2%/78% rain/snow/fair weather conditions, respectively.

The markedly superior transmission efficiency of 765 kV transmission is attributable to its higher operating voltage and thermal capacity/low resistance compared to 500 kV and 345 kV. Furthermore, by unloading the underlying, lower-voltage systems with higher resistance, overall system losses are reduced.

Q13. What is the difference between AC and DC transmission? Which do we prefer, why?

AC (or alternating current) transmission refers to the transfer of energy from a source to one or more main receiving stations by electric current that reverses (alternates) its direction at regular intervals. DC (direct current) transmission involves the transfer of energy from a source usually to one receiving station by electric current that flows in one direction.[1]

Key advantages of AC transmission technology are its flexibility and widespread use by electric utilities. AC facilitates future additions of intermediate stations, acting like exit and entrance ramps on an interstate highway, to serve local load centers and/or provide transmission access for new generation that may locate along the way. The ease of AC connections can encourage siting of fuel-diverse, newer technology and environmentally-friendly generators. Also, the use of AC technology enables expansion into a high-capacity transmission overlay that can be readily integrated with the existing systems. Integration can be achieved using commonly available step-down autotransformers or generator step-up transformers, offering the benefits of enhanced operating flexibility and reduced system losses.

By contrast, traditional DC technology is best suited for specialized applications, such as point-to-point transmission traversing unpopulated areas or where the systems being connected do not operate in synchronism. Examples include underground/undersea cables, long-distance overhead transmission serving as outlets for generating stations, and asynchronous links between two systems that have either no ties or very weak ties. While DC offers freedom from line charging currents and simpler line design with only one (monopolar) or two (bipolar) power conductors, it requires DC/AC conversion at each terminal to integrate with the existing system.[2]

Sources:
[1] "EPRI Transmission Line Reference Book – 200 kV and Above," Third Edition, Electric Power Research Institute, December 2005.
[2] "AEP Interstate Project: 765 kV or 345 kV Transmission," R. Gutman and A.D. Pugh, www.aep.com/about/i765project/technicalpapers.aspx, April 24, 2007.

Q14. What are some of the new technologies we are assessing for inclusion in our existing and new lines for reliability enhancement or other purposes?

AEP has committed to deploy state-of-the-art transmission technologies as part of its vision for a national interstate transmission system, announced in January 2006. The system, dubbed I-765™, will utilize individual phase controls and other advanced technologies to maximize power-carrying capacity and reliability that will establish the standards and benchmarks for 21st century interstate transmission. These technologies, some of which were pioneered by AEP, include: (1) 765 kV AC transmission with six-bundle advanced conductors, (2) phase and shield wire transposition, (3) fiber-optic shield wires, (4) wide-area monitoring and control, (5) remote station equipment diagnostics, (6) single-phase operation, (7) switchable shunt reactors, and (8) static var compensators with enhanced controls.

In addition, AEP, jointly with ABB, a supplier of power equipment and solutions to the utility industry, is developing new transmission technologies for deployment at 765 kV. The newest technology concepts that are: (a) independent phase operation, whereby a conventional three-phase line would remain in service with two phases only following a sustained single-phase fault to allow for reliable redispatch of the system, (b) "dead tank" 765 kV circuit breakers with closing resistors and/or synchronized switching to improve system reliability, and (c) innovative techniques for reducing 765 kV line and equipment losses to achieve still greater transmission efficiencies and reduce the need for new generating plants.

Source:
"AEP Interstate Project: Technologies for 21st Century Transmission," R. Gutman, www.aep.com/about/i765project/technicalpapers.aspx, April 6, 2006.

Q15. What are our views on composite core cables?

Composite core conductors are part of a general class of conductors termed "High Temperature, Low Sag (HTLS) Conductors" and are utilized on the AEP transmission system. HTLS conductors exhibit less sag at elevated operating temperatures than traditional conductors. Composite core conductors carry a significant cost premium and are most cost effective when installed on existing transmission structures as a quick, effective means to increase the thermal capacity of an established transmission corridor. They are stronger and, when built with trapezoidal strands, are more compact and have lower resistance than conventional round-strand conductors with the same diameter. We are working with the industry to advance this emerging technology expecting to see a robust future for HTLS conductors and, specifically, for composite core conductors. AEP has approximately 70 circuit miles of composite conductor installed or planned on five different projects.

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