operation remain unresolved. Current underground cable systems above 400kV are primarily located overseas in Japan, Europe and the Far East, and mostly consist of self-contained fluid filled (SCFF) high voltage cable systems. SCFF high voltage underground cable systems use paper insulated or laminated polypropylene paper insulation. Newer cable technology uses a high-voltage extruded dielectric insulation of cross-linked polyethylene (XLPE). Applications of 500kV XPLE are minimal to date and limited to short *distance* transmission lines. Very few 500kV XLPE and SCFF underground cable systems have been installed and are operating in the world, and only one short length of SCFF installation occurs in the U.S. The longest installation of 500kV underground XLPE cable is in Tokyo, Japan. This project is approximately 25 miles long and has extruded splices.

High voltage underground transmission lines have markedly different technological requirements than lower voltage underground distribution lines. Underground high voltage transmission lines require extensive cooling systems to dissipate the heat generated by the transmission of bulk electricity. The extremely high cost of large cooling systems and other special design requirements prohibits the application of underground transmission systems for long distance electric transmission.

In addition, the basic cost of an underground a high voltage transmission line would be many times more expensive than the cost of overhead construction. Depending on topography, costs for an underground lower voltage (69kV to 138kV) cable construction typically range from four to six times greater than construction of overhead lines. Actual costs of installed 500kV underground cable systems indicate that the costs could be in the range of 10 to 20 times as much as overhead 500kV(*Edison Electric Institute, July 2006*).

Underground systems would require a pipeline and above-ground ancillary facilities (e.g., oil-pressurizing and pumping stations, cooling stations) to transport cooling oil along the transmission line. Oil-pumping and cooling facilities would be required approximately every 7 to 10 miles along the transmission route and at the originating and terminating substations. In addition to the oil-pumping and cooling facilities every 7 to 10 miles, above ground substation facilities would be required at these same intervals for reactor installation and other voltage control devices.

While underground transmission lines are relatively immune to weather conditions, they are vulnerable to washouts, seismic events, cooling system failures, and incidental excavation. Other possible causes for cable failure include water intrusion into the cable, overheating of the cable, high voltage transients, thermal movement during load cycling and aging of the cable. The repair of high-voltage underground cable systems has relatively long outage times compared to repairs of traditional overhead lines. When a fault occurs the circuit is out of service and cannot be placed back into service until repair and test of the system is completed. Because the cable contains a central hollow duct in the conductor that carries cooling dielectric fluid, outage levels can be lengthy until fluid levels are restored. Qualified cable-splicing personnel may be difficult to retain on short notice. It could take at least 5 to 10 days to mobilize qualified technicians and equipment to splice a failed cable. The estimated minimum outage duration for locating, excavating and repairing a single cable failure is estimated to be at least 20 days. Typically, failures in overhead lines can be located and repaired in a matter of hours. Long-term outages would be unacceptable for a circuit carrying bulk power. Further, it is possible that a loss of coolant fluid could occur and result in environmentally hazardous coolant materials contaminating the surrounding soil. A coolant fluid leak can be caused by several means including thermal expansion and contraction of the cable due to power cycling, ground movement, splice breakage, termination movement, improper installation and a cable fault. The fluid is under pressure, so when a leak occurs, it can spread.