

Transmission Efficiency Initiative: Host Demonstration Project Ground Wire Loss Reduction



Ground wire configuration

Project Scope

In addition to documenting the lessons learned during the implementation and operation of this technology, the project will quantify the impact of the shield wire loss reduction on life cycle carbon footprint and system losses.

American Electric Power has used open loop ground wire systems on five lines (533 miles total). The estimated demand savings reach 3 MW and reduction of energy losses reach 4.5 GWh per year. Similar savings are expected with the application of these technologies in other lines. Through a consistent measurement and verification process, this expected benefit will be quantified and validated during the course of the project.

Technology Description

Power loss occurs in shield wires of ac transmission lines through mutual coupling from the phase conductors of the transmission line. Shield wires have relatively high resistance compared to conventional phase conductors such as aluminum-conductor, steel-reinforced (ACSR). In addition, some induced currents in the shield wires can circulate through the towers to ground, with losses accumulating in the tower footing resistance and ground.

- Evaluate options to reduce losses in ground wires of extrahigh voltage transmission lines
- Monitor before and after energy losses and document the results.
- Benefits include reduced energy losses and reduced carbon footprint.

Reducing the losses can be achieved by breaking the conductive path in the shield wires, or by reducing the mutual coupling with the phase conductors. Breaking the conductive path in the shield wires is known as shield wire segmentation. The shield wires are also insulated from the tower to avoid loop paths. By segmenting the shield wire there is no circulating path for fundamental frequency current induced from the mutual coupling with phase conductors, therefore there is little loss in the shield wire when it is segmented. Because the mutual coupling of the line currents in the phase conductors is the significant factor, losses in an un-segmented shield wire increase with line loading. This technology has been applied extensively in certain countries, but it is not widespread in the United States.

On double-circuit lines on a single tower, it is possible to reduce the coupling to the shield wire by phasing the circuit on one side of the tower in reverse order to the phasing on the other side of the tower (called low-reactance phasing). The lower loss for the shield wire is the result of the significant cancellation of the induced currents from the top two phase conductors that the shield wire experiences because of the phasing. Other benefits include better-balanced line voltages and currents, lower ground-level electric and magnetic fields, lower ground-return currents, and slightly lower losses in the phase conductors. On the negative side, the low reactance phasing causes a slightly higher conductor surface gradient,

which leads to increased corona and corona effects such as corona loss. This method of shield-wire loss reduction is usually of lower cost to implement than segmentation.

Expected Benefits

One or more of the following benefits might be realized through the application of this technology:

- Reduction of power loss in the shield wire of several lines
- Reduction in CO₂ emissions
- Possible ice melting, which reduces line and structural loading. In certain countries, large blocks of ice form around the ground wire during extreme weather conditions. In some cases, utilities apply a continuous current of 500–1000 A to the ground wire in order to melt the ice. Of course, this is possible only if the ground wire is insulated and sectionalized.

Approach for Measurement and Verification

A key objective of EPRI's Transmission Efficiency Initiative is to verify and validate the "actual" benefits realized by the application of the technology using a consistent measurement and verification (M&V) methodology that will be developed as part of EPRI's transmission efficiency research portfolio.

The detailed methodology of M&V will be developed during the course of the project, using the following general approach:

- Demand, energy, and CO₂ savings will be determined based on analytical studies. The method of study for determining shield wire losses is to represent the line segment in detail, using an electromagnetic transients model. The transmission line must be represented accurately, considering imbalances due to tower geometry and absence of phase transposition. A careful electromagnetic transient study will determine the magnitude of the loss reduction expected.
- A method to measure shield current will be developed. The reduction in shield wire current will then be determined for different line loading conditions. This will lead to an industry-accepted methodology for projecting savings from shield wire segmentation.

Project Schedule

The schedule of the project tasks is as follows:

1. Analytical study to evaluate shield wire losses at the existing conditions and the saving that can be achieved by different technologies (segmentation, phasing, and so on).
2. Economic analysis to evaluate the cost and the cost-benefit ratio of the project to determine whether it is cost effective.
3. Detailed engineering design.
4. Measurement of shield wire current in the existing conditions (measurement to be recorded for M&V analysis).
5. Field implementation.
6. Measurement of shield wire current with the shield wire segmented and comparison with former measurements to determine savings.
7. Final project report, December 2011.

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