Making the Economic Case for Innovative HTLS Overhead Conductors

Final Project Report

Power Systems Engineering Research Center

Empowering Minds to Engineer the Future Electric Energy System
Making the Economic Case for Innovative HTLS Overhead Conductors

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PSERC Publication 14-7

September 2014
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Power Systems Engineering Research Center

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Acknowledgements

This is the final report for the Power Systems Engineering Research Center (PSERC) research project titled “Making the Economic Case for Innovative HTLS Overhead Conductors” (project T-47). We express our appreciation for the support provided by PSERC’s industry members and by the National Science Foundation under the Industry / University Cooperative Research Center program.

The authors also thank the industry liaisons for this project: J. Fleeman (AEP), J. Hunt (SRP), R. Kondziolk (SRP), W. D. McLaughlin (Southern Co.), P. Myrda (EPRI), K. Cheung (Alstom Grid), J. Price (CAISO), A. Engelmann (Com Ed), S. Chen (PG&E), H. Chen (PJM), S. Ahmed (SCE), R. J. Beck (Southern Co.), A. Mander (Tri-State), and W. Timmons (WAPA) and D. Osborn (MISO). Several of the authors’ colleagues and students at ASU provided useful comments especially Messrs. B. Pierre and X. Deng and Drs. G. Karady and L. Sankar, and Prof. R. G. Olsen, Washington State University.

One author, Askhat Tokombayev, wishes to express his thanks to his parents, Tulegen and Nailya, for their support and encouragement and to his brother Mirat who for inspiration to strive for continuous improvement. Another author K. Bannerjee wishes to thank his parents.
Executive Summary

Obtaining new right of ways for constructing transmission lines to handle increased demand for power is fraught with regulatory and legal issues and is extremely time consuming (> 10 years). The industry is interested in alternate methods for increasing power transfer using existing right of ways. High temperature, low sag overhead transmission conductors present an attractive option for high priority circuits as they replace existing conductors and carry higher current than conventional ASCR conductors. The impact of higher cost of construction and losses could be offset by power market enhancement. This project evaluates the effects of elevated temperature on conductor strength (Part I), systems (Part II), and economic impact (Part III) of HTLS conductors. Two types of composite cores, ACCR (aluminum conductor composite reinforced) and ACCC (aluminum conductor carbon composite) were evaluated.

The primary concern of the effect of high temperature is on the long-term mechanical strength of the core. The integrity of the core was determined from measurements that involved high temperature and mechanical stresses. It was shown that there are differences in the stability and tensile strength of the two types of composite cores over the temperature range of interest to users, however, the reduction in tension strength would not impact operation for the prescribed temperature range. A combination of diagnostic methods such as dynamic mechanical analysis (DMA), optical microscopy, tensile strength tests and temperature calculations were used to arrive at this conclusion.

The project evaluated the expenditures for transmission line reconductoring using HTLS and the consequent benefits obtained from the potential decrease in operating cost for thermally limited transmission systems. Studies performed considered the load growth and penetration of distributed renewable energy sources according to the renewable portfolio standards for power systems. An evaluation of payback period is suggested to assess the cost to benefit ratio of HTLS upgrades. An important point to make on the interpretation of results of this work, and conclusions, is that HTLS appears to be particularly suited for upgrade of existing transmission circuits.

The project also considered the probabilistic nature of transmission upgrades. The well-known Chebyshev inequality is discussed with an application to transmission upgrades. The Chebyshev inequality is proposed to calculate minimum payback period obtained from the upgrades of certain transmission lines. The cost to benefit evaluation of HTLS upgrades is performed using a 225 bus equivalent of the 2012 summer peak Arizona portion of the Western Electricity Coordinating Council (WECC). The results show that it is possible to justify the use of HTLS in this system in a coordinated expansion plan on the basis of operational cost reduction.

The project investigated the transmission expansion planning (TEP) model in order to make an economic case for the High Temperature Low Sag (HTLS) overhead conductors as one possible option to increase ampacity of the transmission system without having to obtain new right-of-ways (ROWs).
The proposed TEP model is formulated using mixed integer programming and the network model is approximated by the direct current optimal power flow (DCOPF) coordinated with the security constrained unit commitment (SCUC) problem and the piecewise linear loss approximation. The proposed TEP model is numerically tested on a modified IEEE 24-bus test system. It is shown on test cases that HTLS reconductoring is usually preferred when real power losses are ignored. On the other hand, parallel line addition option (with a traditional conductor) is favored when power losses are considered. As expected, system condition, such as overloading magnitude and frequency and the relative cost of each investment option, is shown to be key factors that may affect long-term optimal solution. The results thus demonstrate that when it is possible to add a parallel line in the same right of way, this seems to be a preferred option (with a traditional conductor like ACSR). On the other hand, when such options are not available, reconductoring a line with HTLS (replacing an older conductor with HTLS) seems to be a preferred way to increase the transfer capability within a network without having to acquire additional right-of-ways.

**Project Publications:**


**Student Theses:**
