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# Integration of superconducting cables in distribution networks with high penetration of renewable energy resources: Techno-economic analysis

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ABSTRACT

In the current work the feasibility of integration of High Temperature Superconducting (HTS) cables into distribution networks with the existence of high penetration of renewable energy based distributed resources is investigated. Different scenarios regarding the integration of HTS cables into a typical rural MV distribution network have been analyzed. The analyses were performed in different time horizons such as today, 2030, and 2050. The HV cables, HV overhead lines, and MV conventional cables are compared with the MV-HTS cables regarding technical and economical issues. The results show that as a large amount of renewable energy based DG power is intended to be interconnected into the distribution networks, more benefits can be gained using the HTS cables.



## Introduction

Worldwide it can be clearly seen that the investment in electrical transmission and distribution infrastructures is very important for the power industry professionals. In one side the rapidly growing demand in the highly populated areas and power-hungry in the areas where about 2 billion people still lack access to the electricity [1,2]. In the other side a large amount of decentralized renewable energy based power will be interconnected at the transmission and distribution levels of the power supply system in the industrial countries such as Germany. That presents different challenges to the utilities to find out new solutions using the new technologies to conduct the electricity to where it is needed, safely and reliably [1]. One of the new technologies which will play an important role in the future of the power industry is superconducting. There are different superconducting power systems applications such as superconducting fault current limiters which is used to reduce the fault currents by introducing a larger than normal impedance into the path of the fault current [3,4]. Superconducting cables are also one of the important power applications of the superconducting technology which is suited for densely populated regions [5]. The main advantage of the High-Temperature Superconducting (HTS) cable is the high current carrying capacity compared to the conventional cable with the same diameter. Therefore, the existing Right-of-Way (ROW) can be used for installing HTS cables, that will help to reduce the cost and environmental impacts of the network upgrades [1].

In the past, the practical Low Temperature Superconducting (LTS) cables have stimulated the development of underground cables which are capable of transmitting a huge amount of electrical power. However, the high power needed for refrigeration of the superconducting material has limited the interest of that superconducting cable type. The discovery of HTS in 1986 renewed the interest in many applications of superconductivity, including superconducting power cables [6]. The three most significant advantages of the HTS cable over conventional cable are [7,8]:

- High current capacity in small cross sections.
- No local heat generation even during most overload conditions.
- Reduced power loss.

Most conventional high-power cables are rated at very high voltages (up to 450 kV) in order to minimize the current and therefore, the resistive heating in the conductor. As the superconducting

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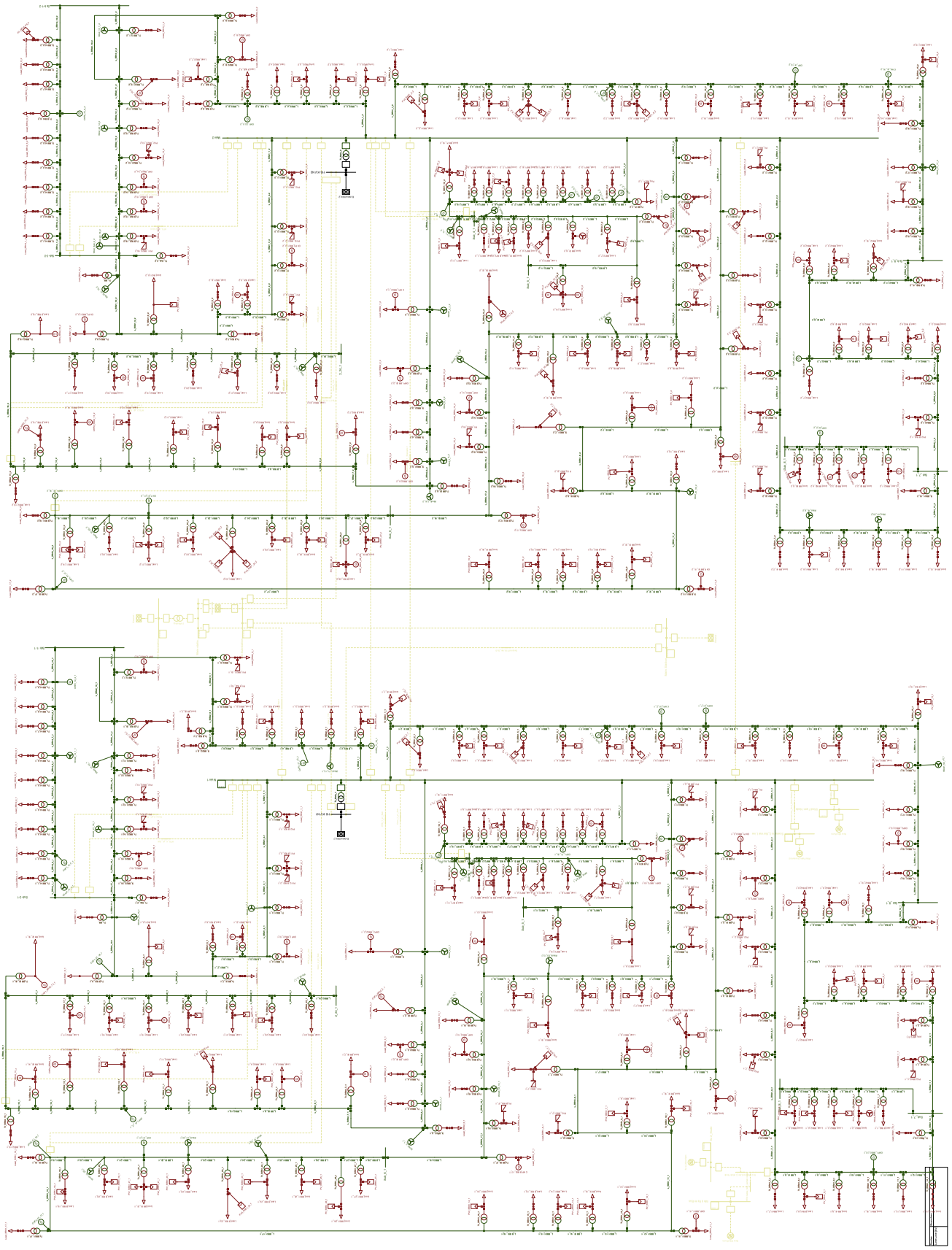

**Fig. 1.** One line diagram of the typical rural network in PowerFactory software.