# Heat dissipation of high voltage cable systems – a technical and agricultural study

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## ABSTRACT

*This paper presents an experiment to determine the influence from heat dissipation of cable systems on the harvest, gained from areas above the route. Experiences with new bedding materials were gained to be taken into account for future projects.*

## KEYWORDS

Bedding material, heat dissipation, agricultural experiments

## INTRODUCTION

Due to the change of the whole power sector in Germany, the grid development leads to certain projects in the EHV grid where partial cabling shall be implemented to gain experience.

A key aspect in designing these cable systems refers to the bedding material. It influences the ampacity significantly. For cable links of "low" transmission capacity, sand was applied and rated to be sufficient. Due to the increasing transmission requirements, accompanied by increasing joule losses and thus increased emitted heat, there was the need to look for bedding materials with lower risk of partial drying out.

The analysis of possible alternatives indicated, that in general, there are materials available fulfilling the more advanced technical requirements. Among those were promising new bedding materials. However there was the lack of experience concerning the behaviour of this new type of bedding material that showed strengths and weaknesses under laboratory conditions.

To qualify these new bedding materials it was decided to launch a field experiment under life conditions and to investigate the thermal properties in detail. Therefore, a new build cable system with a length of about 460 m was equipped with various bedding materials. The applied materials were chosen with respect to their expected performance as well as their acceptance by permitting authorities and landowners.

A second major goal was to gain insight about the influence of the cable system as a heat source on the performance of soil used for agricultural purposes covering the cable route. Therefore, the vicinity of the cable system was equipped with temperature and moisture probes. Right above the cable system, different agricultural crops were cultivated. The harvest gained above the cable route was compared with a control.

## FRAMEWORK CONDITIONS

In the course of extending a substation of Amprion's grid, an infeed from the EHV to the HV grid had to be build. The connection of both grids leads through the substation so it was decided to build a cable connection. The link consists of three circuits with a nominal power of 250 MVA each (corresponding to 1312 A) at an operating voltage of 110 kV.

This link was chosen for testing new bedding materials. Therefore, a testing program was developed. In a first step, the power cables were not connected to the grids. The cables were energized by external circuits injecting controllable conductor currents. By this external heating circuit, the effects of a highly loaded transmission link could be simulated. In a second step, the cable link was connected to the grid and put into commercial operation. All temperature measurements were continued to investigate the heat dissipation when real load profiles were applied.

In 2011, the construction works started. Three pipe systems were built, but only one system was equipped with power cables.

The cables were placed in polyethylene pipes with core spacing of 0.4 m in a core depth of 1.4 m. Due to current rating calculations, the properties of the probably weakest bedding material were applied: For the section, bedded in sand, thermal conductivities of 1.0 W/(K·m) in moist as well as 0.4 W/(K·m) in dry state were assumed. This conservative approach was chosen because there must not be any thermal bottlenecks when the cable link is put into grid operation. The design was done in accordance with IEC publication 60287 [1].

Under these rating conditions, cables with 2000 mm² segmental copper conductors were chosen. The resistance of this conductor type is about 13 µΩ/m at power frequency and at maximum operating temperature.

## TEST SETUP

### Route description

The cable link has a length of 460 m. It was decided to run the field experiment for five different bedding materials: The bedding materials were applied in blocks of 0.5 m corresponding to the Amprion standard as well as of 0.8 m to determine the influence of the height of bedding on the heat dissipation. For cable routes with smaller transmission capacities, Amprion usually applies sand with a grain size of 0-4 mm at a coefficient of uniformity larger than 5. For thermal hotspots, concrete in a weak mixture (low content of cement) is applied. Beside these known materials, the local soil was conditioned with mineral-based compound, elutriated with water and refilled as a suspension. The benefit of this material is that