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Estimation of Thermal Instabilities in Soils around Underground Electrical Power Cables

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The decentralized production of electrical energy from wind requires the installation of more and more underground power cables. From an economic standpoint it is very important to estimate the cables' lifetime, which strongly depends on the temperature. A correct estimation of cable temperature requires an accurate description of the heat balance equation around the cable. Most of the models used to assess heat dissipation from cables, however, do not consider that the soil thermal conductivity strongly depends on soil water content and hydraulic dynamics in the vicinity of the cable. The high temperature around the cable induces a water–vapor cycle in the soil: liquid water evaporates near the cable, and this vapor condensates in the more distant and colder parts of the soil. Above a critical heat dissipation rate, the soil around the cable dries out and the water–vapor cycle breaks down. In this study, we analytically estimated the critical heat dissipation rate as a function of soil type, soil temperature, and water content. We validated the analytical estimation by comparison to a numerical solution of the coupled heat–water–vapor transport for various soil types and conditions. The numerical code was validated by simulating a soil drying experiment. The proposed estimation of thermal instabilities in soils could become a powerful tool in the design of underground electrical power cable systems.