AMPACITY CALCULATIONS FOR LONG AC POWER CABLE CIRCUIT WITH REACTIVE COMPENSATION

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ABSTRACT

In this paper, the ampacity studies are described for a 70 km 110 kV cable line with reactive compensation in the middle of the run. Presence of the reactors changes the current distribution along the cable route making rating calculations difficult. The paper describes a real life case where a special computer program was used to examine electrical and thermal characteristics of this cable line.

KEYWORDS

Cable ampacity, long AC cable lines, reactive compensation.

INTRODUCTION

The project pertains to thermal rating calculations of a 110 kV cable circuit connecting Jasna Wind Farm (WF) to the Gdańsk Błonia substation. The 132 MW Jasna Wind Farm has been in operation for more than a year. It is connected to the PSE Gdańsk Błonia substation by a 110 kV cable line with a route length of 70 km. In the middle of this line there is a compensation station with an 85 MVAr coil. In addition to the coil, there is a system that monitors the temperature in each phase of the cable using optical fibers in the screen. During winter of 2021/22, the maximum recorded temperature was 45°C while the first warning alarm of the system is set at 70°C. The temperature at the interface of the working conductor and XLPE insulation is extrapolated.

The measurements have shown that there is a considerable temperature margin. The owner of the farm, Stadtwerke München (Munich Electricity Company), plans to additionally install a photovoltaic plant of 42.6 MW and further wind turbines of 66 MW with a connection on the 110 kV side at the GPO substation. Feasibility of the extension is also discussed in this report.

It is expected that the limiting parts of the route will be horizontal directional drilling (HDD) under the Vistula River with the length of 1,500 m and under the Nogat River with the length of about 500 m. Calculations need to take into account the fact that PSE takes reactive power on demand at the Gdansk Błonia substation of about 50 MVAr.

This paper provides details of the modeling and the results of calculations.

INFORMATION PROVIDED

Complex calculations performed for this study require large amount of input data. The following additional information for Stage 1 were provided/approved by the client:

1. Detailed cable route data including
   a. Joints, sheath bonding/earthing positions.
   b. Laying data and thermal resistivity-values. This means that whenever a section of the cable route changes either because of the depth of laying or the soil thermal characteristics or the spacing between the cable phases, the length and laying conditions for each section are needed.
   c. Ambient soil temperatures at the laying depths.
2. Infeed or load profile for the steady thermal analysis (time-dependence of the of the real power input).
3. Technical data of compensation reactor including rated power, voltage, operation- or control- mode.
4. Technical data for the new sources of the generated power and nature of their operation.
5. Boundary conditions for the worst operating cases:
   a. max. and min. operating voltages at substation PSE Gdańsk Błonia
   b. max. inductive and capacitive reactive power (or, alternatively, the range of permissible power factor) fed into the cable on the wind farm side
   c. operation- or control- mode of compensation reactor
   d. (n-1)-contingency analysis, e.g. out of operation of the compensation reactor (permanent or temporary).

The data used in the analysis is described below.

Cable data

Two cable cross-sections were used in this project: 1200 and 1400 mm^2 Al with the latter installed under the crossing of the Vistula and Nogat rivers. The cables are XLPE insulated, rated at 64/110 kV (123 kV), and were manufactured by Telefonika Cables. Sheaths of all cables, which change cross sections along the route depending on the calculated short circuit current (95, 160 and 240 mm^2), are cross bonded. A graphical representation of the cable model is shown in Fig. 1 for the sheath cross section of 95 mm^2. Only the 1200 mm^2 construction is shown as the larger cable has only the diameter of the conductor different while the thicknesses of all other components are the same for both constructions. It should be noted that the diameters shown in the model might be somewhat different from those in the data sheet as the manufacturer information contains the tolerances, which are entered as fixed values in the model.