

Interpellation 24.3459: High-voltage lines as overhead lines or underground cables?

Swissgrid's position

Date 16th August 2024

1 Initial situation

On 17 April 2024, National Councillor Emmanuel Amoos (SP) submitted an interpellation entitled «High-voltage lines as overhead lines or underground cables?» with the following text:

«For years, there has been a debate about the advantages and disadvantages of underground power lines compared to overhead lines. The facts are clear today as far as landscape protection and public health are concerned. In economic terms, it has been shown that underground lines offer tangible benefits with regard to energy losses and even costs if the service life of the systems is taken into account rather than merely the construction costs. In addition, public acceptance of a project with underground lines is significantly higher, meaning that the length of the process is reduced accordingly.

As the organisation responsible for the electricity distribution grid in Switzerland, Swissgrid remains somewhat hesitant despite these objective facts, and only uses underground lines for small projects when there is no other option. It also puts these projects at the bottom of its list. An international study led by the Federal Institute of Technology Zurich (ETH) on the main causes of power failures in Europe was published in October 2023. This is the first study to provide a comprehensive overview of the issue in Europe. The researchers analysed 478 power failures that had occurred across Europe in the last 30 years and 14,557 incidents recorded on the Italian grid.

The results showed that the weather was a direct or indirect factor in 90% of these events. Of course, only overhead lines were affected.

It can therefore be concluded that overhead lines have clear weaknesses compared to underground cables as far as the security and reliability of the supply of electricity are concerned.

In view of the above, I would like to ask the Federal Council to answer the following questions:

- Has the federal administration taken the results of the ETH study into account, or does it intend to do so?
- Is the Federal Council (finally) prepared to reverse the rules and to give priority to underground high-voltage lines and only permit overhead lines if cabling can objectively be demonstrated to be impossible and if there is no alternative route that can reasonably be considered?»

2 Overhead lines or underground cabling? The decision lies with the Federal Council.

The [Transmission Lines sectoral plan \(SÜL\)](#) is the Swiss government's superordinate planning and coordination tool for the construction and expansion of transmission lines. For each project, the Swiss Federal Office of Energy (SFOE) appoints a support group made up of representatives of the federal government, the cantons, environmental organisations and Swissgrid.

Overhead lines currently make up 99 percent of the extra-high-voltage grid, as the use of underground cables in the extra-high-voltage grid is relatively new. **Both technologies have advantages and disadvantages** (see Swissgrid brochure on [overhead lines and underground cabling](#)). The ground under an overhead line can be built on without major restrictions, for example, but it impairs the landscape because it remains so visible. However, underground cables also leave traces in the landscape, for instance in the form of aisles in forests, access roads and transitional structures that connect overhead lines to the underground cables. The ground above the cable conduit block can be used again for agriculture and vegetation. As roots could damage the underground cable, however, the route must be kept clear of tall or deep-rooted trees.

The frequency of faults is higher for overhead lines than for underground cables, as they are more exposed to natural influences (e.g. lightning, ice or falling trees). While overhead lines can be made available for use again within a few hours, it can take weeks or months to put underground cables back into operation. The overhead lines in the Swiss transmission grid are equipped with automatic restarting systems. This means that if a sudden disturbance occurs, such as a lightning strike, the line is automatically switched off and switched on again after a few seconds or approximately one minute. Sections with cabling cannot be restarted automatically. This is because a fault on an underground cable is usually associated with damage. The differences in (cable) technologies lie in the insulation material that the conductors are enclosed in, the necessary maintenance and the costs. **The service life of an overhead line is around 80 years, while that of a cable line is around 40 years.**

Swissgrid explores the overhead line and underground cable options for every project. These options are analysed by the support group on the basis of the SFOE's transmission lines evaluation scheme. This scheme consists of four equivalent assessment categories (construction, operation and maintenance of the lines, impacts on the environment and the landscape, and costs). The aim is to find the solution with the highest degree of acceptance. Each category comprises three to four groups of criteria. The support group awards points according to category and criterion. The comparison of the overall score provides a basis for discussion for the support group, which then makes a recommendation. **Ultimately, it is the Federal Council that decides on the planning area, the corridor and the technology (overhead line or underground cabling) of the future line.**

The construction costs of an extra-high-voltage line can vary a great deal from case to case – depending on the topography, subsoil, potential natural hazards and the chosen technology. **As a rule of thumb, a kilometre of underground cable in the transmission system is between 1.5 and 10 times more expensive than a kilometre of overhead line.** When assessing economic efficiency, Swissgrid takes into account not only the construction costs, but also the life cycle costs of the various line variants.

3 Cabling increases the complexity of the overall system

Due to their physical properties, underground cables have an impact on **the stability of the entire transmission system. Underground cables increase the voltage more than overhead lines.** Swissgrid needs to ensure that the voltage across the entire transmission system never becomes too high. The voltage values observed at certain times are already very high and close to the permissible limits for the material. If the proportion of underground cabling in the transmission system increases, Swissgrid must build **compensation systems** that reduce the voltage. However, these systems take up a lot of space, are expensive, require additional energy to operate and cause noise. The reactive power generated by the cables causes an increase in the voltage in the grid and places an additional load on the conductors. For this reason, chokes must be

connected to the cable ends to compensate for the reactive power. These massive structural elements have a major impact on power losses and substantially increase the dimensions of the transition structures.

Furthermore, underground lines have more reactive power when in operation than overhead lines.

Reactive power is useless electricity that «blocks» the line and cannot be converted into another form of energy. This power places an extra load not only on the grid, since the reactive current must be transported in addition to the active current, but also on generators and transformers. Physically, a distinction is made between capacitive and inductive reactive power, which compensate for each other and ideally cancel each other out completely. Swissgrid tries to operate its lines as closely as possible to this point, which is referred to as «natural power». This is not possible with underground cables as they would heat up too much. **This difficulty increases in proportion to the length of the underground cable.** For the 18-kilometre cable project in the Gotthard Road Tunnel, for example, Swissgrid is having to build a compensation system at both ends of the underground cable line in the Airolo substation and in Göschenen to compensate for the reactive power. This is associated with additional costs and energy and takes up more space.

4 Conclusion

The extra-high-voltage grid is reliable and rarely causes interruptions for end consumers (see ECom's reports on «Supply quality»¹).

To summarize, it can be said that partial cabling in the transmission system poses several challenges. From a technical and operational point of view, the degree of cabling should therefore be kept low. Despite the results of the above-mentioned study, it should be noted that overhead lines remain the preferred solution for transmission system operators at international level, primarily for the reasons mentioned above.

¹<https://www.elcom.admin.ch/elcom/en/home/topics/supply-security/supply-quality.html>