No energy transition without high voltage overhead lines

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Summary
The energy transition will dominate for a long time our energy future. With the increased share of renewable energy sources (RES), also the demand of new transmission corridors will virtually explode, the majority of them as overhead lines. This necessity is not always understood by the public, leading often in long delays in the realization of the projects. The contribution will explain the challenges encountered thereby and will present viable options to handle them.

Introduction

High voltage overhead transmission lines look back of over 100 years of successful usage, since they have been first introduced in 1891 in Germany. In the meantime, overhead lines (OHL) have become the indispensable backbone of the electricity grid worldwide, amounting to thousands of line kilometers on all voltage levels. For example, the network of the Transmission System Operators (TSO) in Europe (ENTSO-E) counts more than 200'000 km 380 kV and more than 100'000 km 220 kV lines. The interest in OHL has in the last years because of the integration of RES increased tremendously.

Overhead lines and renewables

OHL have over the years tended to become "business as usual", also suffering from the liberalization of the electricity markets and their partly negative effects on utility investments. This situation has changed dramatically - and positively - in the last years with the worldwide megatrend toward renewables, as shown exemplarily for Germany on fig. 1.

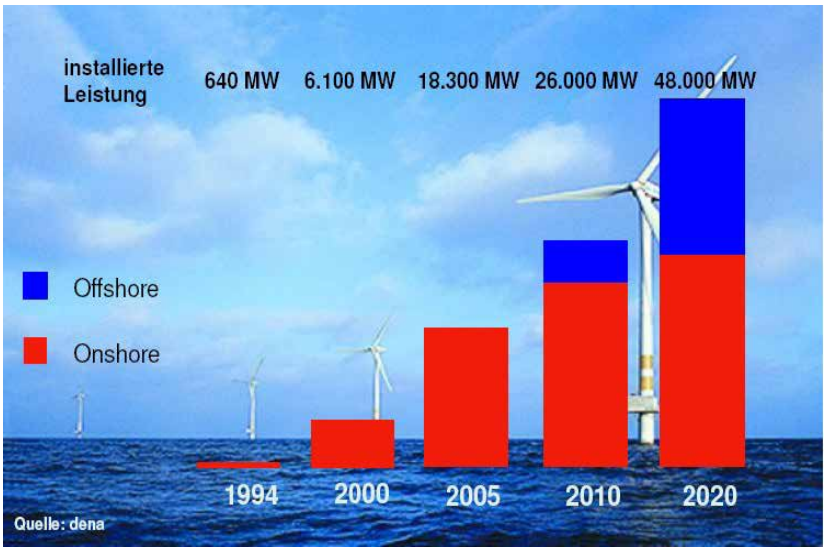

Figure 1: Development of installed wind power in Germany

The result of this development is the requirement for a considerable number of new power transmission corridors, the majority of them overhead. Only in Germany, studies show, that in the next few years there are needed more than 4000 km of 380 kV lines. In this sense OHL are becoming, not only in Europe, "big business", fig. 2. Unfortunately due to he reasons explained below, only a fraction of these projects has been completed on time.

	New Circuits AC and DC >330kV 2013-2022	New circuits AC > 330 kV 2013-2022		New circuits HVDC > 330 kV 2013-2022	
Overhead lines	30,500 km	28,400 km	97.2 %	2,100 km	16.7 %
Sea cables	9,400 km	400 km	1.26 %	9,000 km	71.5 %
Cables on land	1,910 km	420 km	1.44 %	1,490 km	11.8 %
Total	41,810 km	29,220 km	100 %	12,590 km	100 %

Figure 2: Planned network expansion in the EC 10 years development plan

And here comes what I call, faithful to my Greek heritage, the paradox of the OHL business. Technically there is broad agreement that these lines are needed and also financially there are no barriers. The big issue with the system expansion is that there is a strong opposition from the public to new lines, faithful to the well-known NIMB (not in my backyard) principle! This results in approval processes -if they are ever successful- between 10 and 20 years (!) with endless discussions and mainly emotional arguments from the opponents, the media doing their own to keep the fire burning.
In this context CIGRE, the largest and most important non-governmental, non-profit organization in the field of electrical power networks, and in particular its Study Committee B2 on Overhead Lines, play a key role by its Working Groups and publications, [1], to an objective discussion and assessment of these issues.
In this context, a worldwide survey performed by CIGRE SC B2 has confirmed that the low acceptance of new OHL by the public is the main issue of interest - and concern - to the utilities. This is related on one hand to questions about possible health hazards caused by the EMF (Electromagnetic Field) of a line and on the other to - for some - optically disturbing appearance of the line supports, which purportedly have a negative impact on the surroundings. These two issues will be examined in the following.

Electromagnetic fields

Following the megatrend of the growing environmental awareness of the public, this has become a major issue for the industry and is since many years closely monitored by a special purpose, permanent CIGRE working group, WG C3.01. This body has recently published a state-of-the-art report [2]. In this report the considerable efforts of the last years by academia and the industry to establish a relationship between EMF and health are presented. Prac-

tically all studies showed that an association between the presence of power lines and health could not be confirmed.
Many of these studies, [3], were carried out among exposed utility workers, where average fields are up to 20 times - with short exposure periods up to 1000 times – higher than the residential exposure level. Also, those studies failed to reveal an increased risk of cancer, fig. 3. On the opposite, results consistently showed cancer mortality rates 20 to 30 percent lower among workers, compared to the general public, an observation known as the "healthy worker effect".

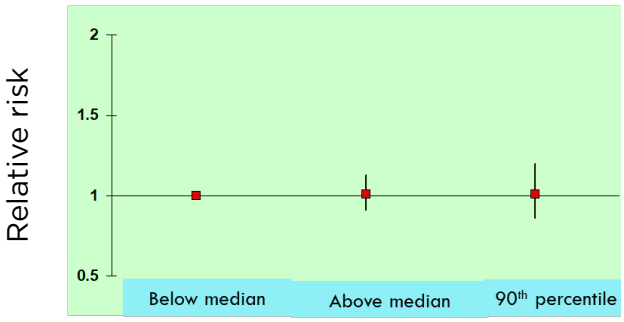

Fig. 3 Cancer among utilities' workers; relative risk factor of 1 means, that despite high EMF exposure, no difference to the general public

Despite the fact that no consistent adverse findings were identified and no particular health effect has been reported, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) has recommended, as a precautionary measure quite low limits to EMF exposure.

Aesthetic line supports
Admittedly the silhouette of some heavy steel lattice towers, can sometimes be difficult to blend with the surroundings. Incidentally this is definitely also the case for some wind power installations, fig. 4.

Fig. 4 Proposal of installation of wind turbines in the Greek island of Serifos

For this reason, it has become in the last years increasingly popular to design overhead lines with aesthetic or landscape supports. i.e. supports which are in a sense related to their environment, like the so-called tennis racket tower, fig. 5, erected near a tennis club in Switzerland [4]

Another alternative are the so-called compact lines. Compact lines have gained considerable interest, not only because of their improved aesthetics and also because of their considerably reduced corridor, the so-called right-of-way [5]. This is nicely visualized on fig. 5, where two 400 kV lines, a conventional and a compact, are shown next to each other [6].

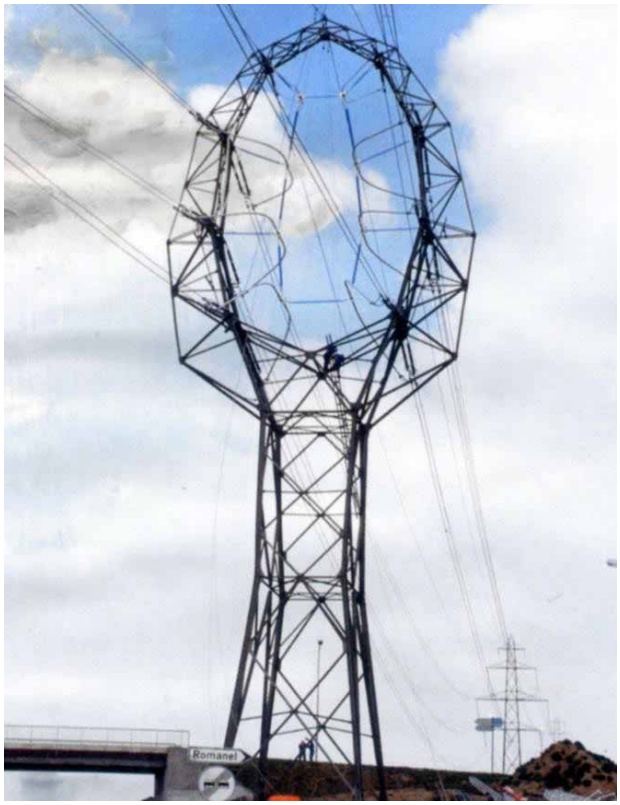

Figure 5. Tennis racket tower

Figure 6: 400 kV compact line (right) parallel to a 400 kV conventional line (left), DEWA, UAE

Conclusion

Overhead transmission lines are again attracting considerable interest by all stakeholders of electrical power networks, as their usage is indispensable for the megatrend of increased integration of renewables in the grid. This goes hand in hand with quite a few challenges they face, mainly aesthetic expectations and worries of EMF from the public. International organizations like CIGRE foster the cooperation of all stakeholders and disseminate valuable, unbiased information in this field. In addition this field will offer numerous job opportunities to young professionals, whether on the technology development, the construction industry and, particular important for Greece, in the software sector in fields like cyber security, smart grids, digitalization of assets, etc.

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