Public acceptance of high-voltage power lines: The influence of information provision on undergrounding

Pascal Lienert⁎, Bernadette Sütterlin, Michael Siegrist

ETH Zurich, Institute for Environmental Decisions (IED), Consumer Behavior, Universitaetsstrasse 22 CHN J 75.1, 8092 Zurich, Switzerland

ARTICLE INFO

Keywords:
- Underground cable
- Public acceptance
- Grid expansion
- Information provision
- Energy transition

ABSTRACT

In Switzerland, the planned transformation of the energy system creates a need for grid expansions. However, grid expansion projects often confront social acceptance issues. The public prefers high-voltage power lines (HVPLs) to be buried underground. Despite the perceived advantages of undergrounding, underground HVPLs can leave visible traces on the surface and are accompanied by electromagnetic field emissions. Given the importance of visual and health impacts on public acceptance of HVPLs, the present study investigates whether providing people with relevant information on these aspects of undergrounding influences people’s perception.

The results show that, after receiving this information, participants viewed underground HVPLs with lower acceptance, lower perceived benefits, higher perceived risks, and less positive feelings. Although public acceptance remained higher for underground HVPLs compared with overhead HVPLs, our study reveals that information provision reduces perceived differences between the two technologies. Furthermore, our results show that affective reactions to underground HVPLs have an indirect effect on public acceptance. We conclude that providing people with relevant information on possible drawbacks related to undergrounding is a necessary precondition for informed decision-making in the context of grid expansions.

1. Introduction

1.1. Swiss energy strategy

Traditionally, the Swiss energy system has mainly relied on hydropower and nuclear power, with over 90% of the country’s electricity production stemming from these two sources. However, following the nuclear accident at Fukushima in 2011, Switzerland decided to make fundamental changes to its energy system. As part of the new energy strategy, the government plans to shut down the country’s five operational power plants until 2050. The share of the electricity portfolio provided by nuclear power is supposed to be replaced by an increase in renewable energy. These developments – along with other measures, such as increases in energy efficiency – are commonly referred to as the “energy transition” in Switzerland. However, the transition from an energy system that is heavily dependent on a few large-scale nuclear power plants to a more decentralized system based on solar and wind power comes with a number of challenges. For instance, the further promotion of renewable energy sources requires adaptations and expansions of the electricity grid. Not only do the renewables themselves need to be connected to the existing grid, but the fluctuating power production of renewables also requires additional electricity storage sites. These storage sites in turn must be connected to the electricity grid, further increasing the need for high-voltage power line (HVPL) expansion (Swissgrid, 2012).

To overcome these infrastructural challenges, the Swiss Federal Council has formulated a new strategy for the development of the electricity grid (Bundesrat, 2013) and has passed an amendment that aims to optimize administrative proceedings in the context of grid expansion projects (Bundesrat, 2016). However, while the optimization of these proceedings constitutes a necessary step toward shortening the duration of planning processes, grid expansion projects also often confront social acceptance issues (e.g., Battaglini et al., 2012; Cohen et al., 2014; Devine-Wright, 2013; Steinbach, 2013). This often results in public opposition, which can lead to delays in or even the abandonment of projects. Since this poses a serious threat to the successful implementation of the energy transition, it is necessary to take a closer look at the factors influencing public acceptance of transmission lines.

1.2. Public acceptance of overhead high-voltage power lines

Besides the influence of project-related factors such as procedural justice (Keir et al., 2014; Zoellner et al., 2008) or trust in authorities (Bronfman et al., 2012; Devine-Wright, 2013; Siegrist et al., 2012),
public acceptance of technology infrastructure projects is mainly influ-
enced by people’s perceptions of risk and benefit (Bronfman et al.,
2012; Huijts et al., 2012) and their affective reactions to the technology in
question (Slovic et al., 2004). According to the affect heuristic (e.g.,
Finucane et al., 2000; Slovic et al., 2007), negative feelings towards a
given technology can lead to lower perceived benefit, higher perceived
risk, and consequently, lower public acceptance. Affect has also proven
to be a relevant factor in the context of HVPL expansions. Lienert et al.
(2017), for instance, showed that the presence of overhead HVPLs neg-
atively affects the affective evaluation of landscapes. Furthermore,
thinking about HVPLs evokes negative feelings, which is related to a
decrease in public acceptance (Lienert et al., 2015).

In addition, several externalities related to HVPLs can negatively
influence the perceived benefits and risks of grid expansions (for overviews,
see Cain and Nelson, 2013; Furby et al., 1988). Besides noise emissions,
effects on property values, and endangerment of local wildlife, two aspects are of special importance: Health concerns due to
electromagnetic fields (EMFs) and the negative impact of overhead
HVPLs on the landscape.

1.2.1. EMFs

From a scientific point of view, it is widely disputed whether elec-
tromagnetic fields caused by HVPLs have a negative effect on human
health. While some studies link EMF exposure to an increased risk of
childhood leukemia (e.g., Draper et al., 2005; Kheifets et al., 2010), no
underlying biological mechanism has been identified that could explain
this finding, and no etiological relation between chronic diseases and
EMF exposure has been established (Ahlbom et al., 2001). Despite this
questionable scientific support, EMF emissions nevertheless play a
major role in people’s perceptions of HVPLs. A survey conducted in
2010 (Eurobarometer, 2010) showed that 70% of European citizens
believed that their health was affected at least to some extent by
HVPLs, and almost half were either very concerned or fairly concerned
about the potential health risk from EMFs. In line with this, in a qua-
litative study Elliott and Wadley (2012) showed that EMFs were rated
the most severe HVPL-related issue.

1.2.2. Negative impact on landscape

Another important reason for the low public acceptance of HVPLs is
their negative influence on landscapes. Tveit et al. (2006), for example,
found that HVPLs are characterized by a lack of contextual fit with their
surroundings, which leads to a disturbance of the visual quality of the
landscapes in which they are sited. This is in line with findings from
Batel et al. (2015), who argue that HVPLs are perceived as an intrusion
on the landscape, especially in rural surroundings, and from Soini et al.
(2011), who determined that residents perceive HVPLs as a negative
landscape element. The significance of the visual impact of transmission
lines on their surroundings is further underlined by Bertsch et al.
(2016). They identified the degree of landscape modification as the
most important driver of acceptance of different energy-related tech-
nologies, including overhead HVPLs.

1.3. The alternative of underground HVPLs

Given the number of problems related to overhead HVPLs, it does
not come as a surprise that there are calls for possible alternatives. One
of the main arguments of opponents to grid expansion projects in this
context is to bury power lines underground (Akademien der
Wissenschaften Schweiz, 2012; Menges and Beyer, 2014). While most
lower voltage power lines are already sited underground, the Swiss
transmission network (220 kV/380 kV) currently consists exclusively of
overhead HVPLs. This situation is comparable with other European
countries, where higher voltage underground cables are rarely used
(Buijs et al., 2011). This is because transmission network operators are
often reluctant to bury HVPLs underground since their installation is
highly complex and underground HVPLs are much more expensive than
overhead HVPLs (National Grid, 2015; Navrud et al., 2008; Swissgrid,
2017).

However, when it comes to public perception, people seem to favor un-
derground cables to overhead HVPLs (e.g., Menges and Beyer, 2014; von
Winterfeldt et al., 2004). In a study conducted in England and Wales,
Atkinson et al. (2006) reported that 87% of respondents preferred under-
ground cables to overhead HVPLs. Similarly, Bertsch et al. (2016) stated
that underground cables were met with much higher acceptance than overhead
lines. This strong preference for undergrounding might be explained by
people viewing underground cables as a way to reduce both the visual and
the health impacts accompanying HVPLs. Navrud et al. (2008), for example,
stated that the avoidance of negative aesthetic impacts constituted a main
social benefit of burying power lines. Regarding EMF emissions, von
Winterfeldt et al. (2004) found that residents favored undergrounding as a
solution to reduce the health effects of HVPLs.

In the face of the perceived advantages of undergrounding and given the
fact that both health and visual impacts are among the most important
drivers of HVPL acceptance, it is understandable that underground cables
are preferred to overhead HVPLs despite the higher costs associated with
them. However, there are also some visual and health drawbacks related to
undergrounding that people might not be aware of.

1.3.1. EMF emissions caused by underground HVPLs

Just like overhead HVPLs, underground HVPLs create electric and
magnetic fields. Nevertheless, due to the special characteristics of cb-
bling, the two technologies have a number of dissimilarities in this
regard. While the electric field of underground HVPLs is completely
screened out by the cables’ insulation, the magnetic field remains un-
affected and occurs on the surface. Since the distance between con-
ductors is much smaller in the case of undergrounding as opposed to
overhead HVPLs, the magnetic field falls more quickly with distance.
This suggests that the magnetic field of overhead transmission lines is
stronger than that of underground HVPLs at distances farther from the
conductors. However, right above and a few meters to the side of an
underground line, the magnetic field is stronger than right below an
overhead line (National Grid, 2015; Swissgrid, 2015; von Winterfeldt
et al., 2004).

1.3.2. Visual impact of underground HVPLs

Underground cables can replace overhead infrastructure such as pylons
and are thus often seen as a means to avoid a negative visual impact on
landscapes. However, depending on the circumstances, underground power
cables can also come with considerable landscape changes (Bertsch et al.,
2016). While the claim that underground HVPLs are invisible on the surface
is true in more urban regions where the ground is made out of concrete, this
might not be the case in more rural regions. In those areas, trees and other
deeply rooted vegetation need to be permanently cut down to prevent their
roots from interfering with the cables and causing outages. Hence, especially
in forested areas, undergrounding may result in visible surface corridors
(ECOFYS, 2008; Swissgrid, 2017).

Another reason why underground lines can come with a considerable
visual impact is derived from the fact that they are currently used mainly for
shorter distances (e.g., Buijs et al., 2011). This means that, in order to cover
longer distances, they are often used in combination with overhead HVPLs.
As a result, sealing-end compounds are needed to connect the two technol-
gies. Due to their size, these can also have a considerable impact on the

1.3.3. Uncertainty related to the perception of underground HVPLs

Despite the fact that underground HVPLs are accompanied by EMF
emissions and have a negative impact on the landscape, research on the
topic is scarce. Although some empirical studies have tried to assess the
perceived benefits of undergrounding by looking at people’s willingness
to pay for this alternative (Atkinson et al., 2006; Navrud et al., 2008;
Tempesta et al., 2014), they have tended to disregard the visual and
health impacts of underground cables. For example, in a literature
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات