The Willingness to Adopt Technologies: A Cross-Sectional Study on the Influence of Technical Self-efficacy on Acceptance

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Abstract. Possible explanations for the acceptance or rejection of technological innovations have become a crucial topic in research. Depending on the type of technology, a variety of factors affect acceptance motives. This paper looks into the influence of technical-self efficacy (TSE) on acceptance of technology infrastructure. An empirical study (n=137 participants) was conducted to study effects of TSE on approval, discomfort, and resistance towards technology infrastructure, using electricity pylons, mobile phone masts, and wind power plants as examples. Overall, it was corroborated that TSE is a key variable for explaining users' acceptance of technology infrastructure. The individual technical self-confidence contributed to the explanation of approval and discomfort, whereas resistance was largely based on place of residence. Acceptance differences between technologies were based on different influential user factors. Our research provides valuable insights for stakeholders and contributes to the research on acceptance of energy infrastructures by providing a cross-sectional view.

Keywords: energy infrastructure, technology acceptance, technical self-efficacy, user diversity, renewable energies.

1 Introduction

The ongoing diffusion of technical innovations in many parts of daily life is an important prerequisite for the wealth of modern societies. Information and communication technologies, as well as industrial production systems and energy technologies, represent essential facilities providing innovations, job security, and electronic services for citizens.

However, with the increasing presence of technology people are confronted with, the acceptance of those technologies and the extent to which citizens are willing to adopt and tolerate these technologies are serious issues and not to be neglected [1],[2]. This is especially true facing the diversity of users who usually not only lack domain knowledge and technical expertise but who also do not possess detailed knowledge regarding the factual consequences of these technical developments.

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The issue of technology acceptance has been researched from multiple perspectives for quite a long time now. It describes the approval, favorable reception, and ongoing use of newly introduced devices and systems.

The majority of theoretical models of technology acceptance refer to the acceptance of information and communication technologies in a mainly job-related context [3]. According to traditional acceptance theories, users' decision to use a novel technology is mainly determined by the perceived ease of use of the technical system and its perceived usefulness [4]. The success of these theoretical models was shown in many studies, but they are restricted to single small devices (e.g., computer, mobile phone) in the working context [5],[6]. It is highly reasonable that technology acceptance and the willingness of citizens to accept large-scale technologies in their living environment is much more complex [7].

Another shortcoming of traditional technology acceptance models is that mostly younger and technology-experienced persons were studied, a group not representative of today's technology users [8]. Beyond age, technology generation, and gender, the technical self-efficacy was found to considerably influence the way and the extent to which persons are willing to accept a (new) technology. Technical self-efficacy refers to the individual confidence in one's capability to use technical devices [9]. Studies have shown that computer self-efficacy is an influential factor for the performance and the ease of use in small screen devices [1], [6], [10]. However, it is unclear to what extent technical self-efficacy has an effect when dealing with large-scale technologies instead of small screen devices.

2 Acceptance of Infrastructure of Different Technologies

Recent technology acceptance research is directed at large scale technologies and infrastructure systems of different technology fields such as base stations [11], [12], Carbon Capture and Storage [13], heating systems [14], geothermal energy [15], photovoltaic systems [16], wind farms [17], renewable energy [18], and biogas [19].

In this context, technology acceptance is predominately related to persons' risk perceptions, i.e., the subjective assessments of the perceived probability and possible outcomes of expected negative events (e.g., natural hazards or environmental threats [20]). Characteristically, risk perceptions are a complex combination of perceived benefits, perceived barriers, and the perceived thread brought by technology interwoven with the individual bias for refusal or resistance.

While recent research considerably augmented the knowledge about technology acceptance in large-scale technologies, so far it is still insufficiently understood in how far risk perception and technology acceptance of infrastructure technologies are impacted by individual characteristics such as technical self-confidence.

In this study, we use an empirical approach to explore the influence of technical-self efficacy on approval, discomfort, and resistance towards technology infrastructure, taking electricity pylons, mobile phone masts, and wind power plants as examples.

3 Methodology

For an online survey, a questionnaire was designed to collect data from respondents on their TSE and their perception of different types of technology infrastructure. For this, electricity pylons, mobile phone masts, and wind power plants were chosen, as they share certain characteristics: all are vertical, lathy constructions that have a vital purpose in daily life. Additionally, they are all associated with health risks that have been widely discussed in the literature: radiofrequency emissions from mobile phone masts, electric and magnetic fields from electricity pylons, and infrasound from wind power plants. Lastly, they are all perceived as visual obtrusions and thus often subject to debate in citizen groups.

Questionnaire Design. The questionnaire included items on demographic information, living area, and proximity to the investigated infrastructure. Furthermore, six questions from the New Environmental Paradigm (NEP) scale [21] were used to measure attitude towards the environment. TSE was measured using selected items from Beier's TSE-questionnaire [9]. Both scales were shortened to assure a manageable length of the questionnaire. Acceptance of electricity pylons, mobile phone masts, and wind power plants was measured using the following seven items (with "x" respectively standing for "an electricity pylon," "a mobile phone mast," and "a wind power plant"). All questions, with the exception of the demographic information, were answered on a six-point-Likert scale ("1=do not agree at all" to "6=fully agree"). Finally, participants were invited to leave comments on the topic.

Table 1. Items used to measure discomfort, resistance, and approval of electricity pylons, mobile phone masts, and wind power plants. The items "unhappy," "controversial," and "protest" were adapted from [22].

Factor	Item name	Label
discomfort	unhappy	I would be unhappy if x was built nearby.
	danger	I think x is dangerous.
	health risk	I fear that x poses health risk.
resistance	controversial	It would be controversially discussed in my neighborhood.
	protest	I would protest against the building of x.
approval	acceptance	I would accept seeing x from my house.
	useful	I find x useful.

Reliability of Scales. To measure reliability of the scales used, a reliability analysis was performed for items used to quantify environmental attitude, TSE, discomfort, resistance, as well as approval of the three technologies (electricity pylons, mobile phone masts, and wind power plants). For the six items used to measure NEP, Cronbach's alpha was 0.72, respectively 0.90 for the eight items on TSE.

Because the scales to measure attitude towards technology infrastructure had not been used before, a factor analysis with Promax rotation was carried out on the items for each technology to verify the separation into the factors "discomfort," "resistance," and "approval." Results of the factor analysis are shown in Table 2.

As can be seen in Table 2, the total explanation of variance for electricity pylons was 78.33%, for mobile phone masts 79.97%, and for wind power plants 83.08%.

The three factors for each technology were also tested for reliability by applying Cronbach's Alpha as a measure of internal consistency. For electricity pylons, CA was reported between 0.48 and 0.85. For mobile phone masts, CA resulted between 0.59 and 0.88. The CA for factors on attitude towards wind power had a CA between 0.66 and 0.84. All factors were thus considered sufficiently reliable.

Table 2. Means, SD, and factor loadings for items on infrastructure acceptance

Factor	Variable	M	SD	Loading	Explanation
electricity pylons **discomfort**	unhappy elec	3.9	1.4	0.82	50.13%
	danger elec	3.0	1.2	0.91	
	health risk elec	3.3	1.3	0.96	
electricity pylons **resistance**	controversial elec	4.3	1.4	0.88	10.67%
	protest elec	2.9	1.3	0.18	
electricity pylons **approval**	acceptance elec	3.8	1.3	0.92	17.54%
	useful elec	4.1	1.2	0.68	
mobile phone masts **discomfort**	unhappy mobile	4.0	1.4	0.89	55.01%
	danger mobile	3.6	1.3	0.98	
	health risk mobile	3.7	1.3	0.97	
mobile phone masts **resistance**	controversial mobile	4.2	1.4	1.03	9.95%
	protest mobile	3.1	1.3	0.30	
mobile phone masts **approval**	acceptance mobile	3.6	1.3	0.62	15.00%
	useful mobile	4.0	1.2	1.00	
wind power plant **discomfort**	unhappy wind	2.9	1.5	0.38	57.22%
	danger wind	2.0	1.1	1.02	
	health risk wind	2.1	1.2	1.04	
wind power plant **resistance**	controversial wind	4.0	1.5	1.08	14.22%
	protest wind	2.2	1.3	0.57	
wind power plant **approval**	acceptance wind	4.3	1.4	0.69	11.64%
	useful wind	5.0	1.2	1.09	

Data Collection. A pretest was arranged with n=5 participants to ensure comprehensibility of the tasks. Their answers were not included in the analysis. After the evaluation of the pretest and minor modifications to the original questionnaire, data were collected in an online survey in Germany, between December 2013 and January 2014. The poll took approximately 15 minutes to complete.

3.1 Sample

137 participants took part in the study (47% women, 53% men). The mean age was 34.2 years (SD=13.3). Half of the sample reported to hold a university degree, 16% had completed vocational training. 44.5% lived in the city center, 37.5% in the

outskirts, and 19% in a village. To control for regular exposure to the investigated infrastructure, we asked if respondents lived within view of electricity pylons, wind power stations, or mobile phone masts (Fig. 1).

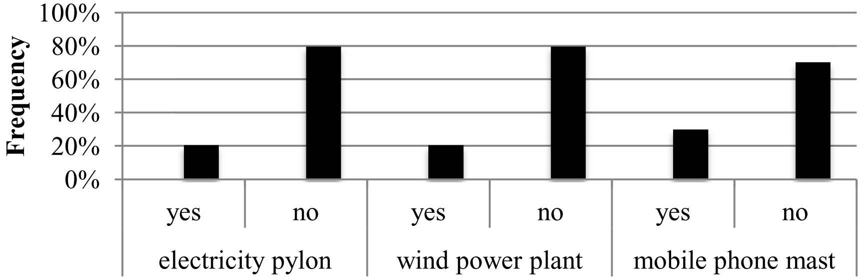

Fig. 1. Do you live within view of...? (n=137)

The mean score for TSE for the sample was M=4.7 (out of 6 points maximum) (SD=0.9). TSE correlated significantly with age (r=-0.20, p≤ 0.05). A significant gender difference for TSE between male (M=5.1, SD=0.6) and female participants (M=4.2, SD=1.0) was revealed (F(1,135)=36.5, p≤ 0.01). The mean score for environmental attitude was M=4.8 (6 points maximum) (SD=0.7), with no significant gender differences. Further analyses revealed no significant differences for TSE or environmental attitude. However, a significant age effect occurred (F(2,134)=17.47, p≤ 0.01): The further participants lived outside the city center, the older they were.

4 Results

In a first step, mean scores for the factors discomfort, resistance, and approval were calculated for each technology. Results are shown in Fig. 2. Resistance was almost

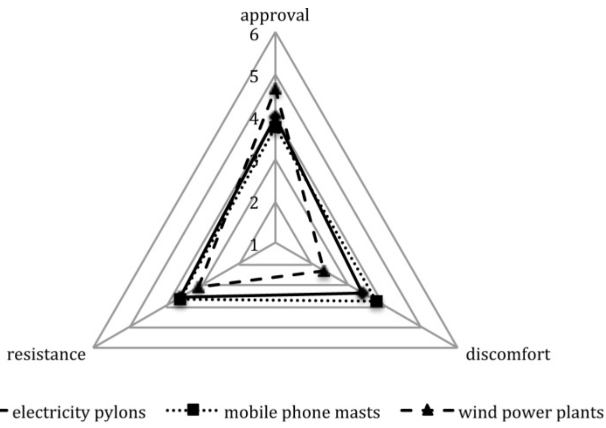

Fig. 2. Mean scores for factors resistance, discomfort and approval for electricity pylons, mobile phone masts, and wind power plants (1= do not agree at all, 6= fully agree)

identical for mobile phone masts (M=3.6, SD=1.2) and electricity pylons (M=3.6, SD=1.1), while wind power plants scored slightly lower (M=3.1, SD=1.2). Discomfort was also similarly high for mobile phone masts (M=3.8, SD=1.2) and electricity pylons (M=3.4, SD=1.1), but it scored considerably lower for wind power plants (M=2.3, SD=1.1). Accordingly, approval was the highest for wind power plants (M=4.7, SD=1.2), with lower scores for electricity pylons (M=4.0, SD=1.0) and mobile phone masts (M=3.8, SD=1.1).

Next, the influence of user characteristics on the three different factors was analyzed for all three technologies. First, correlations (Pearson's r) were run for continuous variables (age, TSE, environmental attitude) to identify possible influence factors on resistance, discomfort, and approval. Figures 3 to 5 show the significant correlations.

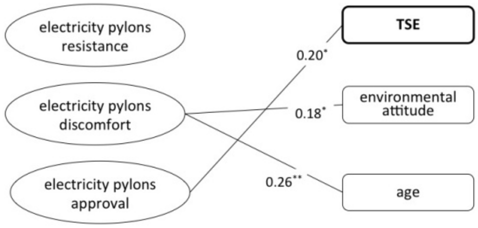

Fig. 3. Significant correlations between attitude towards electricity pylons and user characteristics (Asterisks indicate significance: * p≤ 0.05, ** p≤ 0.01)

It was found that electricity pylons and mobile phone masts show a similar pattern with regard to significant correlations, not only for the variables involved but also for the direction of the correlations. For both technologies, environmental attitude correlates positively with discomfort and TSE correlates positively with approval. Age, in both cases, is correlated positively with discomfort. Additional significant correlations for mobile phone masts were age and approval (negatively correlated) and environmental attitude and resistance (positively correlated).

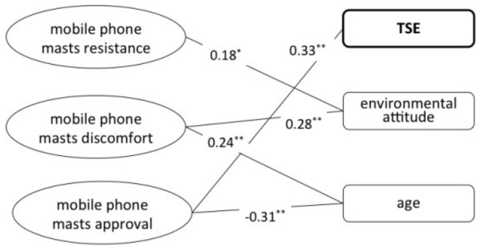

Fig. 4. Significant correlations between attitude towards mobile phone masts and user characteristics (Asterisks indicate significance: * p≤ 0.05, ** p≤ 0.01)

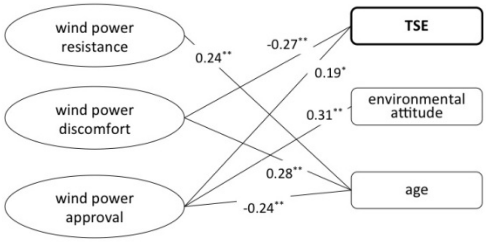

Fig. 5. Significant correlations between attitude towards wind power plants and user characteristics (Asterisks indicate significance: * p≤ 0.05, ** p≤ 0.01)

The pattern for wind power plants presented a direct contrast to this. Here, environmental attitude correlated positively with approval and not with discomfort. TSE did not merely correlate significantly with approval but also with discomfort. Age correlated significantly with all three factors.

Similarities for all three technologies can be found in the fact that age always correlated positively to discomfort and TSE always correlated positively with approval. Significant effects of nominal variables (gender, living within view of respective technology, place of residence) on attitude towards the three technologies were calculated using AVONAS by defining the nominal variables as independent (IV) and the attitude factors as dependent variable (DV). No significant differences between groups were reported for gender and participants who lived within or out of view of the respective technology infrastructure. No significant differences in attitude towards mobile phone masts were detected for groups based on the place of residence. For the attitude towards wind power plants and electricity pylons, however, place of residence played a significant role (Table 3): People who lived closer to the city center show less resistance and more approval towards wind power plants and less discomfort and resistance towards electricity pylons. This tendency is also supported by the non-significant factors for electricity pylons and wind power values.

More than one user factor showed to be influential for attitude towards the different technologies. Therefore, step-wise multiple regression analyses were performed for resistance, discomfort, and approval to identify the factor that predicts each mindset the best. Results are shown in Fig. 6 (electricity pylons), Fig. 7 (mobile phone masts), and Fig. 8 (wind power plants).

TSE significantly contributed to the prediction of approval for mobile phone masts and electricity pylons. For mobile phone masts, TSE ($\beta = 0.27$, $p<0.01$) and age ($\beta =-0.25$, $p<0.01$) contributed almost equally ($F(2,134)=13.41$), whereas for electricity pylons, TSE was the sole variable with significant contribution ($F(1,135)=5.62$) to approval. Furthermore, it was found that age significantly predicted discomfort for electricity pylons ($\beta = 0.28$, $p<0.01$), as did environmental attitude ($\beta = 0.21$, $p<0.05$) ($F(2,134)=8.37$). Age and environmental attitude combined also explained 15% of the variance for discomfort in the context of mobile phone masts ($F(2,134)=11.92$), both variables contributing similarly (age: $\beta = 0.28$, $p<0.01$, environmental attitude: $\beta = 0.31$, $p<0.01$). In addition, environmental attitude was identified as the single predictor for mobile phone mast resistance ($F(1,135)=4.43$). Resistance against electricity pylons, in contrast, was predicted solely by place of residence ($F(1,135)=6.52$).

Table 3. ANOVAS for place of residence (IV) and attitude towards wind power plants (DV)

Place of residence	**Dependent variable**	**M**	**SD**	**df1**	**df2**	**F**	**Level of significance**
city center	wind power plant **approval**	4.9	1.1	2	134	3.73	$p \leq 0.05$
suburbs		4.6	1.2				
village		4.2	1.2				
city center	wind power plant **resistance**	2.9	1.1	2	134	4.56	$p \leq 0.05$
suburbs		3.1	1.3				
village		2.6	1.1				
city center	wind power plant **discomfort**	2.1	0.9	2	134	3.01	n.s.
suburbs		2.5	1.2				
village		2.6	1.1				
city center	electricity pylons **approval**	4.1	1.1	2	134	1.86	n.s.
suburbs		3.9	0.9				
village		3.7	1.0				
city center	electricity pylons **resistance**	3.4	1.1	2	134	3.43	$p \leq 0.05$
suburbs		3.6	1.1				
village		3.9	1.2				
city center	electricity pylons **discomfort**	3.2	1.1	2	134	3.86	$p \leq 0.05$
suburbs		3.5	1.1				
village		3.9	1.4				

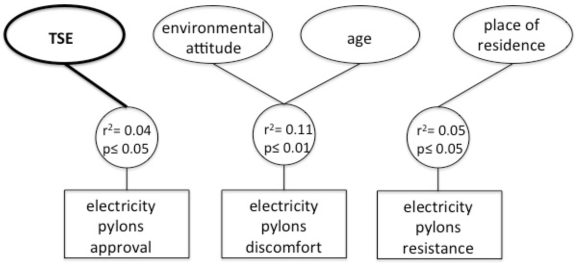

Fig. 6. Regression analysis for attitude towards electricity pylons

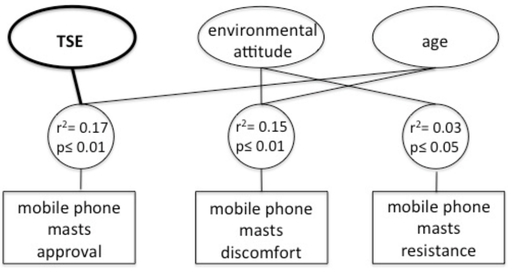

Fig. 7. Regression analysis for attitude towards mobile phone masts

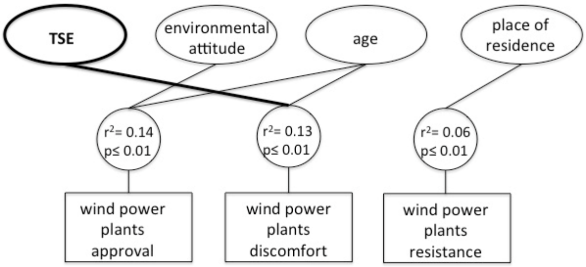

Fig. 8. Regression analysis for attitude towards wind power plants

Contrary to the findings for electricity pylons and mobile phone masts, TSE was found to be a predictor for discomfort for wind power plants (β = -0.22, p<0.01), as was age (β = 0.24, p<0.01) (F(2,134)=9.70). Another difference is the fact that environmental attitude (β = 0.28, p<0.01) in combination with age (β = -0.21, p<0.05) was found to predict approval for wind power plants, not discomfort. As it was for electricity pylons, place of residence was the only predictor for wind power plant resistance (F(1,135)=8.68).

TSE significantly contributed to the prediction of approval for mobile phone masts and electricity pylons. For mobile phone masts, TSE (β = 0.27, p<0.01) and age (β =-0.25, p<0.01) contributed almost equally (F(2,134)=13.41), while for electricity pylons, TSE was even the only single variable with significant contribution (F(1,135)=5.62) to approval.

It was found that age significantly predicted discomfort for electricity pylons (β = 0.28, p<0.01), as did environmental attitude (β = 0.21, p<0.05) (F(2,134)=8.37). Age and environmental attitude combined also explained 15% of the variance for discomfort in the context of mobile phone masts (F(2,134)=11.92), both variables contributed similarly (age: β = 0.28, p<0.01, environmental attitude: β = 0.31, p<0.01). Additionally, environmental attitude was identified as the single predictor for mobile phone mast resistance (F(1,135)=4.43). Resistance against electricity pylons, in contrast, was predicted solely by place of residence (F(1,135)=6.52).

Contrary to electricity pylons and mobile phone masts, TSE was found to be a predictor for discomfort for wind power plants (β = -0.22, p<0.01) besides age (β = 0.24, p<0.01) (F(2,134)=9.70). Another difference is the fact that environmental attitude (β = 0.28, p<0.01) in combination with age (β = -0.21, p<0.05) was found to predict approval for wind power plants, and not discomfort. Place of residence, like for electricity pylons, was the only predictor for wind power plant resistance (F(1,135)=8.68).

5 Discussion

In this empirical approach, we explored the acceptance of infrastructure systems in the context of renewable energy technologies, using electricity pylons, mobile phone masts, and wind power plants as examples.

Connecting to outcomes in other studies which corroborate the considerable impact of user characteristics on the extent to which users are willing to adopt novel technologies [1] ,[5], [8], we looked into the influence of technical-self efficacy (TSE) on acceptance of technology infrastructure in terms of individual approval, discomfort, and resistance towards said infrastructure. We also looked into the effects of the participants' age and their levels of environmental awareness: age, we found out, was also connected to their TSE levels.

The discussion section first focuses on how TSE influences attitudes towards electricity pylons, mobile phone masts, and wind power plants, then turns to other variables that have been identified to play a key role. Next, the results will be discussed, comparing the three different technologies.

Across the three technologies under study, it could be shown that TSE played a significant role for acceptance: the higher the levels of technical self-confidence, the higher the approval of infrastructure technologies (electricity pylons, mobile phone masts). Also, TSE was found to impact the discomfort regarding wind power plants (the lower TSE, the higher the discomfort ratings). Apart from place of residence, TSE was the only user factor that served as a single predictor for explaining technology acceptance for large-scale technologies. Beyond TSE, the participant's age was also an important factor. The fact that age affected approval and discomfort for mobile phone masts could be due to belonging to different technology generations [23]. Technology generation means the mental model of technology of a respective time and its influence/availability during the upbringing of the participants. From the voluntary comments given by participants, one (by a 57 years old male person) reflects the technology-generation related attitude towards mobile phone masts:

> "Pull down as many masts as possible. Imagine that I have survived my childhood and youth without any mobile phones. True emotions can much better be transmitted without electronic devices, but face to face. And (…) I have managed to start my family, even without any smartphones." (m, 57 y)

The study also revealed interesting differences across the three infrastructure technologies. While electricity pylons and mobile phone masts received almost comparable ratings for participants' resistance, discomfort and approval, wind power plants were overall perceived as much more positive. The difference between the large-scale technologies could be explained by the fact that wind power plants are a symbol of an environmentally friendly generation of electricity and thus evoke (mostly) positive associations. This is supported again by the comments that were given at the end of the questionnaire. It is striking that, in contrast to electricity pylons and mobile phone masts, wind power plants are connected with more positive associations: They are perceived as "beautiful" and "elegant," as "useful," "ecologically friendly," and as "the future" or "modern." Even though there were, of course, also negative associations ("infrasound," "dangerous for birds"), it is evident that its overall evaluation is more positive in comparison to the other two large-scale technologies. On the basis of the present data, this difference cannot be conclusively resolved. In future studies, we will have a look into mental models and images of those technologies. One assumption is that persons might be more affirmative towards wind power plants because they are perceived as successors of "windmills" which carry a positive connotation and reflect the good old days [24].

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