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# The evaluation of hydrogen fuel stations by citizens: The interrelated effects of socio-demographic, spatial and psychological variables

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## ABSTRACT

Hydrogen fuel use in vehicles can potentially have positive effects on the environment. The placing of hydrogen fuel stations may, however, be influenced by citizens' responses to them. The current study, therefore, investigates the determinants of citizens' evaluations of the local implementation of a hydrogen fuel station (called public acceptability). The effects of socio-demographic, spatial and psychological variables are analyzed with the use of regression analyses and structural equation modeling. The results show that the psychological variables explain public acceptability better than the socio-demographic and spatial variables. The strongest predictors are positive affect, negative affect, expected local effects and expected societal and environmental effects. The effects of the determinants on public acceptability are mostly in the expected direction. The effects of most spatial and socio-demographic variables are fully mediated by the psychological variables. An interesting finding is that citizens living nearer to a fuel station location are more negative about the placing of a hydrogen fuel station there than citizens living further away. This is in line with the idea of Not In My Backyard (NIMBY), but contrary to findings in previous hydrogen fuel station acceptability studies. The analyses indicate that those living nearer have a more negative evaluation because they have a lower level of trust in the industry placing and maintaining a safe hydrogen fuel station and less strongly experience positive affect when thinking about the placing of a local hydrogen fuel station. Copyright © 2015, Hydrogen Energy Publications, LLC. Published by Elsevier Ltd. All rights reserved.

## Introduction

Hydrogen fuel use can potentially make car use less dependent on fossil fuels, less carbon intensive, less polluting and less noisy [1–4]. Worldwide, hydrogen fuel stations are currently being implemented [see e.g. [5–8]]. However, many

more need to be installed to make the use of hydrogen vehicles attractive for a substantive share of car users [4,9]. A potential barrier or delaying factor to implementing hydrogen fuel stations is opposition by citizens living nearby, as happened in the past in Washington and London [10–13]. In the current study we focus on gaining insight into the factors

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that determine how citizens evaluate the placing of a local hydrogen fuel station, called in short public acceptability [14].

A few studies on the topic of hydrogen fuel station acceptability can be found in the literature. Mumford and Gray [10] used a qualitative approach. They found that in London a lack of trust and perceived risks were important reasons for citizens to oppose a local hydrogen fuel station. Two studies have used a quantitative approach; one study performed in the UK investigated the support for or resistance to the storage of hydrogen at a fuel station location [15], while a study performed in Norway looked into the determinants for support for or resistance to a hydrogen fuel station [16]. These two studies tested the effect of a diverse set of variables, including socio-demographic factors, the spatial factor distance and the psychological variables knowledge and trust. The former study [15] found that opposition could be significantly predicted by age, income, plans to stay living there for at least five more years, being bothered by the existing fuel station, membership of a local residence association, attendance of meetings associated with planning issues, knowledge about hydrogen as a fuel, environmental attitude and trust in safety regulations. Support in this study was explained by a subset of these variables. The latter study [16] found that support was explained by gender, residential area, knowledge about hydrogen as a fuel, environmental knowledge, attitude about the importance given to solving environmental problems, and attitude towards the role of science and technology in solving environmental problems. Other studies have looked at the acceptability of other single hydrogen technologies or of a mix of hydrogen technologies [17–21], or have studied citizens' intentions to take action in favor of or against a hydrogen fuel station as a dependent variable [22,23].

The current study is also a quantitative study into the public acceptability of a hydrogen fuel station and aims to contribute to the literature in four ways. First, contrary to previous studies, it includes psychological factors that are also known to be important determinants of technology acceptability: perceived costs, risks and benefits of the technology and positive and negative affect [14,24,25]. Second, it will measure the psychological variables with several items each. In the previous studies, the variables were measured with one item each while the measurement of these constructs is known to be sensitive to the precise formulation of the questions and can even consist of multiple dimensions which cannot be captured in one question. Examples of those variables are knowledge and trust [26,27]. Third, we will test the direct and indirect effects using structural equation modeling as it can be presumed that the different determinants of acceptability also influence each other. It is, for example, likely that the psychological variables mediate the effect of socio-demographic and spatial variables on acceptability. The interrelations between predicting variables were not taken into account in previous studies. Fourth, the current study investigates the acceptability of hydrogen fuel stations at many different locations throughout the country, the Netherlands in this case. Previous studies measured the acceptability of a single hydrogen fuel station. As each fuel station location may have specific conditions which influence the acceptability of placing a hydrogen refueling facility there, the findings at one location may not be transferable to other

fuel station locations. A specific condition included in our study is the type of area where the refueling is going to be placed in—in a residential area, industrial area or environmental or natural area.

The current study has two main aims. First, it aims to test the effects of a wide range of variables including spatial, socio-demographic and psychological variables. We aim to identify which factors affect citizens' acceptability levels and which do so more strongly than others. Second, it aims to gain insight into how the different variables influence each other and how psychological variables mediate the effect of the socio-demographic and spatial variables. This provides insight into the effect of variables when controlled for other variables and gives insight into how more 'proximal' factors (the psychological variables) mediate the effect of more 'distal' factors (socio-demographics and spatial factors).

The paper is organized as follows. **Theoretical background: selection of variables and expected relations between variables** summarizes the literature and formulates expectations about the effect of potential determinants on hydrogen fuel station acceptability and interrelations between determinants. **Methodology** describes the research method and the measurements taken. **Results** describes the results and conclusions per variable. **Discussion** includes the discussion, with overall conclusions, limitations and recommendations.

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## Theoretical background: selection of variables and expected relations between variables

Literature on the acceptability<sup>1</sup> of both debated energy technologies such as nuclear power plants and windmills and of locally unwanted land uses (LULU's) such as landfills and nuclear waste storage will be reviewed. These two domains of literature appear to be not often brought together, but are both likely to hold relevant insights for renewable energy technology siting projects [28].

### Socio-demographic variables

Socio-demographic variables have been found to influence the acceptability of land uses and technological projects, such as a waste isolation plant [income, education, age and gender, 29] and power lines [education, 30]. Socio-demographic variables have also been found to influence the acceptability of hydrogen fuel stations; the hydrogen fuel station in Norway was more often supported by men than by women [16] and the hydrogen storage facility in London was more often opposed by respondents with a lower income and by respondents that were older than by respondents with a higher income and that were younger [15]. Based on these findings about hydrogen fuel stations, we may expect that men, younger citizens, and citizens with a higher income are more positive about hydrogen fuel stations than women, older citizens, and

<sup>1</sup> Often these studies use other words than acceptability, such as acceptance, support or opinions. In general, with the word acceptability we refer to measurements related to attitudes/opinions of citizens towards a locally unwanted land use or debated technology.

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