



Original research article

## The emotional dimensions of energy projects: Anger, fear, joy and pride about the first hydrogen fuel station in the Netherlands

Nicole M.A. Huijts\*

Ethics and Philosophy of Technology Section, Department of Values, Technology and Innovation, Faculty of TPM, Delft University of Technology, Delft, The Netherlands



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## ABSTRACT

Citizens' emotional responses to energy technology projects influence the success of the technology's implementation. Contrary to popular belief, these emotions can have a systematic base. Bringing together insights from appraisal theory and from technology acceptance studies, this study develops and tests hypotheses regarding antecedents of anger, fear, joy, and pride about a local hydrogen fuel station (HFS). A questionnaire study was conducted among 271 citizens living near the first publicly accessible HFS in the Netherlands, around the time of its implementation. The results show that anger is significantly explained by (from stronger to weaker effects) perceived procedural and distributive unfairness, and fear by distributive unfairness, perceived safety, procedural unfairness, gender, and prior awareness. Joy is significantly explained by perceived environmental outcomes and perceived usefulness, and pride by prior awareness, perceived risks, trust in industry, and perceived usefulness. The study concludes that these predictors are understandable practical and moral considerations, which can and should be taken into account when developing and executing a project.

## 1. Introduction

Citizens' emotionally-charged responses can delay or even prevent the introduction of energy projects into society. One well-known example involves a canceled carbon capture and storage project in the Netherlands [1,2]. Many other energy projects, such as wind parks, high-voltage power lines, and nuclear power plants have also been vocally and emotionally opposed by citizens.

Emotions about new technologies have often been viewed negatively. They are said to result from ignorance and to undermine the decision-making process, which should ideally be based in rational weighing of risks and benefits [3,2]. For that reason, emotions have been ignored or taken at face-value by decision-makers [4]. Some scholars have argued, however, that emotions are helpful, valuable, and even necessary for making practical and moral judgments [5,6] and result from, or co-occur with appraisals of the situation (e.g. [7,8]). This claim has been made about energy projects in particular [9,10]. Understanding what underlies citizens' emotions about new energy projects can help developers, policymakers, and industry managers to design better technologies, policies, and communications, and to undertake more ethically acceptable and practically accepted enterprises.

Studies of technology acceptance and risk perception (see for overviews [11,12]) have focused mainly on the positive or negative

valence of feelings measured as affect, and rarely on specific emotions (with the exception of Dohle et al. [13]). Emotion scholars, however, have shown that different emotions of the same valence (e.g. anger and fear) can have different antecedents and lead to different behaviors [14–16]. This suggests that it is valuable to gain more insight into specific emotions towards new technologies.

This paper develops hypotheses about antecedents of specific emotions based on findings from appraisal theory and from technology acceptance studies, and tests these hypotheses for emotions about a local hydrogen fuel station. Two negative emotions (anger and fear) and two positive emotions (joy and pride) are considered. These four distinguishable emotions relate to different appraisals and behaviors [17,15,16,18].

Unlike anger, fear, and joy (e.g. [16,19]), pride has not often been studied; this is particularly true of pride in parties other than oneself or one's offspring [20]. As pride has been shown to motivate people to persevere in a task despite initial costs [21], it is important to understand what generates pride in an energy project.

### 1.1. The case of a Dutch hydrogen fuel station

Hydrogen has the potential to make car use independent of fossil fuels and free from harmful emissions, provided that the hydrogen is produced with sustainable energy sources [22–24]. However, early

\* Present address: Eindhoven University of Technology, Postbox 513, IPO-building 1.26, 5600 MB Eindhoven, The Netherlands.  
E-mail address: [n.m.a.huijts@tue.nl](mailto:n.m.a.huijts@tue.nl).

experiences have shown that resistance to HFS projects can arise because of concerns about safety risks, especially when the HFS is located near private residences [25–28].

The current study focuses on an HFS that was placed in the city of Arnhem in 2010. Biogas was purchased for the on-site generation of the hydrogen, making it a low-carbon fuel. The project was initiated and subsidized by regional governmental bodies, and it was owned by a non-profit organization run by industry partners. The HFS was added to an existing petrol station, which was located in an industrial area, close to a residential neighborhood and to the local bus company that would deploy one hydrogen bus. Nearby-living citizens were not involved in decision-making about the project. The official opening generated a few short news items in local newspapers and on national television [29–31].

## 1.2. Theory

Appraisal theory, which assumes that specific emotions are triggered by appraisals of a stimulus [7,8], can shed light on the role of specific emotions in the context of environmental risk perception (cf. [32]). The theory holds that specific emotions are keyed to certain appraisals, such as “novelty, intrinsic pleasantness, certainty, goal significance, agency, coping potential and compatibility with social or personal standards” (the latter including fairness; [7,p. 573]). These appraisals explain not only elicitation of emotions but also differentiation among emotions. For example, events that people feel they cannot cope with are more likely to cue fear, while events that people feel they can cope with are more likely to cue anger [19].

This study focuses on four sets of potential antecedents of specific emotions about energy projects: (1) perceived outcomes, (2) procedural and distributive fairness, (3) prior awareness, and (4) trust. These antecedents are related to several appraisals, namely goal significance, fairness, novelty, agency, control, and coping ability.

### 1.2.1. Goal significance and perceived outcomes

Goal significance or goal relevance distinguishes among the occurrences of specific emotions in appraisal theory. The theory holds that specific emotions are preceded by or co-occur with appraisal of the “extent to which a stimulus or situation furthers or endangers an organism’s survival and adaptation to a given environment, the satisfaction of its needs, and the attainment of its goals” [7,p. 578]. Scherer, in fact, makes goal significance a crucial part of the definition of emotion, which he sees as “an episode of interrelated, synchronized changes in the states of all or most of the five organismic subsystems in response to the evaluation of an external or internal stimulus event *as relevant to major concerns of the organism*” (Scherer, 1987, 2001 in [60,p. 697] [my emphasis]).

Arguably, having a safe living environment, energy security (including access to useful vehicle fuels), and minimal environmental degradation (e.g. limited air pollution and climate change) is an important goal for many citizens in the context of energy technologies [33]. It can therefore be presumed that the more one believes that an energy technology will positively or negatively affect these goals, the stronger one’s positive or negative emotions respectively will be.

Hydrogen as a fuel for vehicles is often perceived as having environmental benefits and safety risks [34–39]. The more positive environmental outcomes people expect the technology to have, the more joy and perhaps also pride they are likely to report upon the opening of a local HFS; conversely, the more risks people expect the technology to have, the more anger and fear they are likely to report. By the same token, the anticipated usefulness of a local HFS will probably determine the amount of joy and pride people report. While joy may simply be caused by the expectation of a project’s positive outcomes, pride may specifically result from awareness of an outstanding achievement by a party that one feels connected to. Although pride is often associated with personal achievement [15,21], people can also feel pride in the achievements of other community members [20]. It is difficult to

predict which of the outcomes will be considered most outstanding and most linked to local community members, and thus most likely to elicit pride.

### 1.2.2. Fairness: procedural and distributive

Appraisal researchers have found that also perceived unfairness is a strong predictor of specific emotions. For example, Frijda et al. [40] discovered that unfairness cued anger when people recalled their own recent emotions. Scherer [19] demonstrated that perceived unfairness was the second-strongest predictor (after the dimension of agency or causation) of specific emotions that people associated with recent events. Furthermore, Mikula et al. [41] showed that appraisals of an event’s unfairness most strongly induced anger, but also elicited other negative emotions, such as sadness, fear, guilt, and shame. In the context of technology acceptance, Dohle et al. [13] showed that perceived fairness explained the intensity of anger—but not of fear—around mobile phone base stations. These studies, however, did not specify the type of fairness.

Technology acceptance research has determined that both procedural fairness and distributive fairness affect how people evaluate energy technologies [42,12,43]. While procedural fairness relates to how a decision-making procedure takes place (for example, whether citizens’ opinions are being listened to), distributive fairness relates to how the positive and negative outcomes of a technological project are allocated. In the justice literature, procedural and distributive unfairness have been recognized as distinct moral factors; both have been found to cause anger [44]. A study of a hypothetical hydrogen fuel station [45] has confirmed that distributive unfairness explained negative affect, which was measured as the average rating of several negative emotions, including anger and fear. These findings suggest that perceived procedural and distributive unfairness will elicit anger, and possibly also other negative emotions such as fear, when an energy project is developed in one’s vicinity.

### 1.2.3. Novelty and prior awareness

Novelty is one of the appraisal dimensions that predicts which specific emotions arise. Scherer [19], for example, showed that different emotion-eliciting events rate differently in expectedness; unexpected events cued anger, while expected events cued joy.

Citizens living near a new energy project may be more or less aware of it. When asked for their opinion about this project, they may therefore experience novelty to a greater or lesser extent. Thus, prior awareness may influence which specific emotion is felt more strongly. Scherer’s findings on novelty [19] imply that prior awareness elicits more joy and less fear than prior unawareness. Similarly, it may be that pride is higher and fear lower among those who were already aware of the fuel station than among those who were not.

Those with prior awareness of hydrogen as a fuel were more likely to support than to oppose a hypothetical hydrogen fuel station [27]. Similarly, support for the use of hydrogen vehicles in London was higher among citizens who already knew of them [46]. Prior awareness, then, favorably affects how people evaluate hydrogen technologies and leads to more positive and fewer negative feelings about them.

### 1.2.4. Agency, control, coping ability and trust

In different domains, trust plays a very important role in how people evaluate and respond to a situation and its social context (e.g. [47–49]). Specifically, trust seems to shape affective evaluations of potentially risky technologies; trust in three different institutions that were responsible for the use of nanotechnology in the food domain influenced the average affective evaluation of associations with nanotechnology applications [50]. Higher levels of trust in industry and in government engendered more positive and less negative affect regarding carbon capture and storage [51]. For a hypothetical hydrogen fuel station, less trust in industry lead to stronger negative affect, and more trust in the municipality to stronger positive affect [45].

When the overall affective evaluation of technologies is influenced by trust, then it is likely that specific emotions will also be so influenced. Appraisal theory, however, does not explicitly include trust as one of its dimensions. Empirical studies that draw on appraisal theory have also overlooked trust as a factor that explains which specific emotion is felt. In line with this, Scherer [65, p. 643] has written that “appraisal theory has largely neglected the social context in which emotions are elicited, possibly requiring appraisal criteria relevant to relationships and interaction strategies.” Thus, trust in those responsible for the technology is a promising candidate to fill this gap in the context of new energy projects.

In the case of potentially risky technologies, trust is related to three appraisals: agency, control, and coping potential. For a project like a hydrogen fuel station, agency lies largely with the industry that is designing, installing, managing, and maintaining it. This industry, not the citizens, has control over the risks associated with the technology. For this reason, rather than assessing their own personal ability to prevent and cope with the negative outcomes of the technology, citizens may wonder how well the industry is able to do so. Presumably, though most people will assign all or most of the agency to the industry, they may differ with respect to how well they expect it to install and maintain a safe technology. This will be reflected in people’s level of trust. Agency, control, and coping ability have all been found to explain and differentiate among emotions, and therefore trust can also be expected to do so. The question is, which emotions are influenced by trust and which are not?

When it comes to a new HFS being placed in the vicinity, it is likely that lower levels of trust in the industry will cause more strongly felt fear (about possible negative outcomes) and anger (towards those who are in charge). Higher trust, on the other hand, may mitigate expectations of terrible accidents, which may in turn limit fear and anger. On the positive side, when trust in the industry is higher, people may experience more joy when thinking about the technology and more pride when anticipating outstanding local achievements.

### 1.3. The current study

To summarize, this study seeks to explain the strength with which anger, fear, joy, and pride about the first Dutch hydrogen fuel station are felt by citizens living in its vicinity. The following hypotheses are tested:

1. Anger and fear will be felt more strongly when people perceive more risk and more procedural and distributive unfairness, and when they have no prior awareness of the HFS and less trust in the industry that is responsible for the technology.
2. Joy and pride will be felt more strongly when people perceive better environmental outcomes and more usefulness for those living nearby, and when they have prior awareness of the HFS and more trust in the industry that is responsible for the technology.

The study also asks whether those with and without prior awareness display similar or different relations between antecedents and emotions. People who have prior awareness of a technology not only experience less novelty but also have had more time to think carefully about the HFS. This may give them the opportunity to appraise the situation differently, and may thus affect the relation between antecedents and emotions. Finding few or no interaction effects of prior awareness with other antecedents, however, would suggest that the antecedents of specific emotions about the local HFS are quite stable.

## 2. Method

A paper-and-pencil survey was conducted among residents living in the vicinity of a new hydrogen fuel station, shortly before and after its official opening on December 3rd, 2010. The selected neighborhoods were close to the center of town, and they had a mixed population of lower- and higher-income residents, including quite a few students.

### 2.1. Sample

In total, 329 people filled in the questionnaire between November 2010 and May 2011. These respondents were living between 143 and 1400 m away from the fuel station.

After the removal of questionnaires that were missing information about any of the four emotions or about any of the seven antecedents, 271 questionnaires remained. Of those, 153 were filled out at most three weeks before the official opening of the hydrogen fuel station, and 110 were filled out at most six months after the opening. Eight questionnaires might have been completed before or after the opening. As there was no reason to believe that the timing of the questionnaire influenced the relation between antecedents and emotions, the before and after samples were treated as one sample.<sup>1</sup>

In total, 47% of the respondents were female and 52% male (1% did not specify their sex). Ages varied from 20 years to 90 years, with a mean of 41 years ( $SD = 13$ ), and 11% of the respondents did not specify their age. The gender distribution and average age can be considered reasonably representative of Dutch society as a whole ([www.cbs.nl](http://www.cbs.nl)).

A majority of the respondents (64%) was highly educated, having at least a BSc degree. 36% had a lower education, and less than 1% did not answer this question. According to the Dutch Bureau of Statistics ([www.cbs.nl](http://www.cbs.nl)), in 2010, only 28% of the Dutch population up to 65 years old had received higher education. As 96% of our sample consisted of people younger than 66, it can be concluded that the sample has a higher percentage of highly-educated people than does the Netherlands as a whole.

Respondents were also asked whether they rented or owned their home. 52% of the respondents were renters, and 48% were homeowners.

### 2.2. Measurements

Anger, fear, joy, and pride were measured by asking people to rate the extent to which they experienced a number of different emotions when thinking of the local HFS, on a scale from 0 (‘not at all’) to 5 (‘very strongly’). See Table 1 for the distribution, mean and standard deviation of the answers. 135 people rated one or two emotions higher than zero, and 78 rated three or four emotions higher than zero. This shows the commonness of blended and mixed feelings, which is in line with previous emotion research (e.g. [40,53]).

The perceived environmental outcomes were measured with three items related to the effects of hydrogen fuel on (a) air quality, (b) the environment, and (c) the climate – along with one item related to the effect of the local HFS on the environment. The scale ran from 1 (‘very bad’) to 5 (‘very good’). The four items were averaged ( $M = 4.21$ ,  $SD = 0.64$ ,  $\alpha = 0.81$ ).

The perceived safety was measured with two items on a scale ranging from 1 to 5, concerning the safety of (a) hydrogen as fuel for vehicles and (b) the local hydrogen fuel station. The scale ran from 1 (‘very dangerous’) to 5 (‘very safe’). The two items were averaged ( $M = 2.67$ ,  $SD = 0.76$ ,  $\alpha = 0.67$ ).

The perceived usefulness was measured with one item, by asking to what extent the respondent thought that the local hydrogen fuel station would be useful for people living nearby ( $M = 3.04$ ,  $SD = 0.94$ ), on a scale from 1 (‘very useless’) to 5 (‘very useful’).

<sup>1</sup> When testing for the direct effects of questionnaire timing (before or after the official opening) on the four emotions, and when testing for interaction-effects between the time of filling in and the expected antecedents of the emotions, only one significant effect was found. The influence of perceived environmental benefits on pride was moderated by whether the questionnaire was filled out before or after the official opening of the HFS. Treating the before and after groups as separate samples, it became clear that before the opening, the perceived environmental effects did not significantly explain pride ( $\beta = -0.07$ ,  $p = .44$ ), while after the opening, the perceived environmental effects did significantly explain pride ( $\beta = 0.25$ ,  $p = .01$ ). To keep the dataset as large as possible for further analyses, the two datasets were subsequently treated as one sample.

**Table 1**  
Descriptions of emotion measurements.

N = 271	Anger	Fear	Joy	Pride
0 (not at all)	203	175	89	98
1 (very little)	36	51	47	37
2	12	19	22	26
3	16	19	69	53
4	2	5	30	38
5 (very strongly)	2	2	14	19
Means	.46	.65	1.80	1.83
SD	.97	1.08	1.62	1.72

The perceived procedural fairness was measured with three items. First, respondents were told that the municipality had decided to install the local HFS and had been responsible for granting the permit for its operation. They were then asked to what extent they agreed with the following statements: (a) 'I think that the municipality communicated openly about how the decision-making has taken place,' (b) 'I think that the interests of all parties have been weighed in a careful manner,' and (c) 'I think that the procedure for granting the permit has taken place in a fair way.' The scale ran from 1 ('I totally disagree') to 5 ('I totally agree'). The three items were averaged ( $M = 3.11$ ,  $SD = 0.79$ ,  $\alpha = 0.85$ ).

The perceived distributive fairness question was preceded by a short explanation that 'The drawbacks and benefits are not equally distributed over all inhabitants of an area. The subsidies given by the government are carried by the whole society. The benefits for the environment and the use of the fuel, and the risks, are experienced differently by different people.' Then the question was posed: 'What do you think about the distribution of benefits and drawbacks, for yourself and others, that derive from the new hydrogen fuel pump at the fuel station at Van Oldenbarneveldtstraat 91?' The scale ran from 1 ('very unfair') to 5 ('very fair'); from 1 ('not a problem') to 5 ('very much a problem'); and from 1 ('very much unavoidable') to 5 ('very avoidable'). It was presumed that the more problematic and avoidable an unequal distribution was perceived to be, the more unfair it would be considered. The latter two items were reverse coded and the three items averaged, such that 1 means 'very unfair/problematic/avoidable' and 5 'very fair/unproblematic/unavoidable' ( $M = 3.23$ ,  $SD = 0.62$ ,  $\alpha = 0.65$ ).

Prior awareness was measured with the question 'Did you know, before you received our letter or questionnaire, that a hydrogen fuel station had been built in Arnhem?' A sizeable minority of 35% answered yes; 65% answered no.

Trust in the industry was measured as trust in the hydrogen fuel station supplier's and in the fuel station owner's ability to install and maintain a safe technology. The four items measured the level of agreement with four statements relating to trust of these two parties: (a) that they had installed a safe refueling facility, (b) that they had the knowledge and experience to do so, (c) that they intended to do so, and (d) that they paid appropriate attention to the facility and performed safety checks. The scale ranged from 1 ('I do not agree') to 5 ('I agree'). The four items were averaged ( $M = 3.70$ ,  $SD = 0.80$ ,  $\alpha = 0.90$ ).

The measurements used in this study are similar to measurements reported by Huijts et al. [45], as the two studies' questionnaires were designed in parallel. The questionnaire for the current study included many more items than the ones reported here.<sup>2</sup>

### 3. Results

#### 3.1. Means and correlations

Table 2 reports the correlations between all the psychological variables. It shows that emotions of the same valence were positively correlated, with correlations between 0.66 and 0.78. Emotions of

different valences were also positively correlated, but only weakly, ranging from 0.10 to 0.17. The antecedents were not at all to moderately correlated to each other.

T-tests were used to determine whether there are differences in the ratings of the emotions between men and women, between people with lower and higher levels of education, and between owners and renters. No significant differences were found, except where gender and fear were concerned: women rated fear more strongly than men (women:  $M = 0.81$ ,  $SD = 1.24$ ; men:  $M = 0.50$ ,  $SD = 0.88$ ;  $t(227.15) = 2.39$ ,  $p = .02$ ). To control for this effect, gender was added to the following analyses. To maximize the number of data points, the two missing values of gender were replaced with the mean value (1,5). Correlations between age and the dependent variables were also tested: there were no significant correlations.

#### 3.2. Antecedents of emotions

To test the two hypotheses, a set of regression analyses was conducted in which each emotion was regressed on all the antecedents and on gender (see Model 1, Table 3). To check whether there were differences in the effects of the antecedents on the emotions between respondents who had versus respondents who did not have prior awareness, the interaction effects of prior awareness with the other antecedents were added to the analyses in a second step (see Model 2, Table 3). Prior to the analyses, the variables were mean-centered to reduce problems with multicollinearity.

##### 3.2.1. Anger and fear

Hypothesis 1 stated that anger and fear will be felt more strongly when people perceive more risk and more procedural and distributive unfairness, and when they have no prior awareness of the HFS and less trust in the industry that is responsible for the technology.

Table 3, Model 1 shows that people indeed felt significantly angrier when they perceived more procedural and distributive unfairness. However, the findings did not confirm that anger is significantly explained by perceived risks, trust in industry, or prior awareness.

Furthermore, Model 2 shows that there was a significant interaction effect of prior awareness with perceived environmental outcomes, although the explained variance of Model 2 was not higher than that of Model 1. The unstandardized  $\beta$  for the influence of perceived environmental outcomes on anger is  $-0.17$  for the group that had no prior awareness, and  $0.43$  for the group that did have prior awareness of the local HFS (see also Fig. 1, left image). It is possible that several respondents who had prior awareness of the HFS project, and who perceived more positive environmental outcomes of hydrogen fuel use, were angry because they felt that the project was not doing enough to create a cleaner and sustainable transportation system.<sup>3</sup> A local newspaper had reported on opening day that four vehicles would refuel at the HFS, and that hydrogen technology for other cars was not yet available [29]. This might have supported the idea that public money had been misused or that too little effort and too few investments had

<sup>3</sup> An additional variable that was measured but not reported was environmental problem perception (see also [45]). This variable measured the scope and likelihood of expected problems with climate change and air pollution in the coming 20 years, due to the current use of fuels in transport. In the group that had prior awareness, higher environmental benefits had a significant positive correlation with environmental problem perception ( $r^2 = 0.28^{**}$ ,  $p = .01$ ), and anger was significantly positively correlated with environmental problem perception ( $r^2 = 0.22^*$ ,  $p = .04$ ). The same correlations in the group that did not have prior awareness were not significant, had higher p-values, and were smaller in effect size ( $r^2 = 0.11$ ,  $p = .17$  and  $r^2 = 0.10$ ,  $p = .19$  respectively). This shows that among those with prior awareness of an HFS project, those who indicated larger and more likely problems with climate change and air pollution due to current fuel use at the same time anticipated greater environmental benefits from the HFS and from hydrogen fuel use in general; they also reported greater anger when thinking of the project. In this group, anger may thus have resulted from the fact that people think that the HFS is not a good or sufficient way to address serious environmental problems.

<sup>2</sup> The full questionnaire (in Dutch) can be obtained from the author.



**Table 2**  
Correlations between variables.

		Correlations									
		1	2	3	4	5	6	7	8	9	10
1	Anger										
2	Fear	.76**									
3	Joy	.15*	.15*								
4	Pride	.17**	.10	.67**							
5	Perceived environmental outcomes	-.14*	-.16**	.30***	.27***						
6	Perceived safety	-.18**	-.25***	.24***	.34***	.41**					
7	Perceived usefulness	-.10	-.09	.25***	.23***	.22**	.32**				
8	Perceived procedural fairness	-.27***	-.25***	.18**	.19**	.17**	.21***	.22***			
9	Perceived distributive fairness	-.24***	-.30***	.13*	.19**	.20**	.17**	.05	.18**		
10	Prior awareness (0: no, 1:yes)	-.08	-.14*	.10	.19**	.09	.04	-.17**	.08	-.04	
11	Trust in industry	-.18**	-.29***	.24***	.32**	.29***	.33***	.16*	.29***	.35***	.04

\*\*\* p < .001.

\*\* p < .01.

\* p < .05.

**Table 3**  
The four emotions regressed on antecedents. Betas (p-values) are reported.

Dependent Variable:	Anger	Fear	Joy	Pride
<b>Model 1</b>				
Gender (male)	-.09 (.129)	-.13* (.022)	.01 (.886)	-.01 (.917)
Environmental outcomes	-.01 (.859)	.02 (.743)	.18** (.006)	.07 (.250)
Risks	.09 (.177)	.16* (.017)	-.05 (.468)	-.18** (.005)
Usefulness for local citizens	-.03 (.694)	.00 (.996)	.18** (.004)	.15* (.015)
Distributive unfairness	.16** (.009)	.19** (.001)	-.02 (.762)	-.07 (.256)
Procedural unfairness	.21** (.001)	.15* (.017)	-.06 (.305)	-.04 (.470)
Trust in industry	-.02 (.809)	-.12 (.052)	.12 (.079)	.18** (.004)
Prior awareness (no-yes)	-.07 (.220)	-.12* (.037)	.11 (.050)	.19** (.001)
R <sup>2</sup>	.13	.20	.16	.23
<b>Model 2</b>				
Gender (male)	-.07 (.271)	-.11 (.066)	.01 (.849)	.00 (.994)
Environmental outcomes	.03 (.710)	.05 (.427)	.19** (.004)	.09 (.177)
Risks	.10 (.162)	.16* (.017)	-.05 (.502)	-.19** (.004)
Usefulness for local citizens	-.02 (.778)	.01 (.895)	.19** (.003)	.14* (.020)
Distributive unfairness	.16* (.012)	.19** (.001)	-.02 (.364)	-.05 (.404)
Procedural unfairness	.21** (.001)	.15* (.015)	-.06 (.314)	-.05 (.383)
Trust in industry	-.02 (.816)	-.13 (.050)	.12 (.072)	.17** (.007)
Prior awareness (PA)	-.08 (.197)	-.13* (.027)	.11 (.058)	.19** (.001)
Environmental outcomes * PA	.17* (.011)	.13* (.047)	.07 (.258)	-.02 (.702)
Risks * PA	.09 (.194)	.07 (.313)	.01 (.895)	-.09 (.144)
Usefulness for local citizens * PA	.06 (.347)	.01 (.880)	.01 (.835)	-.03 (.625)
Distributive unfairness * PA	-.01 (.830)	-.04 (.567)	.06 (.365)	-.04 (.510)
Procedural unfairness * PA	-.00 (.966)	-.00 (.967)	.02 (.783)	-.07 (.276)
Trust in industry * PA	-.04 (.555)	.03 (.701)	.06 (.345)	.06 (.379)
R <sup>2</sup>	.16	.22	.17	.25
ΔR <sup>2</sup> (as compared to model 1)	.03 (n.s.)	.02 (n.s.)	.01 (n.s.)	.02 (n.s.)

N = 271; \*\*\* p < .001; \*\* p < .01; \* p < .05; n.s.: not significant.

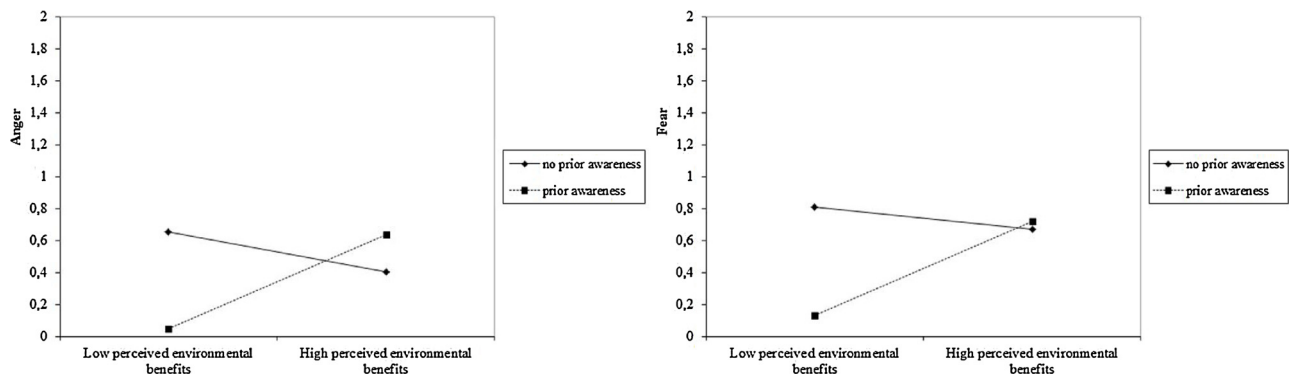


Fig. 1. Relationship between perceived environmental benefits and anger (left image) and fear (right image), depending on prior awareness.

been made.

No other significant interaction effects between prior awareness and other antecedents of anger have been found, which suggests stable relationships between antecedents and anger.

Furthermore, Table 3 also shows that the level of fear was indeed significantly higher when people perceived more distributive unfairness, more risk, and more procedural unfairness – and when they did not have prior awareness of the HFS (these factors are listed in order from strongest to weakest effect). Again, women reported significantly more fear than men. Trust in industry had as strong an effect on fear as did prior awareness, but the effect was only marginally significant ( $\beta = -0.12$ ,  $p = .052$ ); as expected, fear was higher when a lower level of trust in the industry was reported. Overall, fear was motivated by more factors than was anger.

Model 2 shows a significant interaction effect of prior awareness with perceived environmental outcomes, although the explained variance of Model 2 was not significantly higher than that of Model 1. The unstandardized  $\beta$  for the influence of perceived environmental outcomes on fear is  $-0.09$  for the group that was not aware, and  $0.42$  for the group that was aware of the local HFS (see also Fig. 1, right image). It may be that some respondents who had prior awareness of the HFS project, and who expected more positive environmental outcomes, reported more fear because only one fuel station would not make much of a difference; perhaps they feared the negative outcomes of climate change and other environmental problems that one small project could not sufficiently address. No other significant interaction effects between prior awareness and other antecedents of fear have been found, which suggests stable relationships between the other antecedents and fear.

### 3.2.2. Joy and pride

Hypothesis 2 stated that joy and pride will be felt more strongly when people anticipate more positive environmental outcomes and more usefulness of the HFS for people living nearby, and when they have prior awareness of the HFS and more trust in the industry that is responsible for the technology.

The findings confirm that associating the HFS with environmental benefits and local usefulness does indeed cause people to experience significantly higher amounts of joy. Joy was felt marginally more strongly when people had prior awareness and when they had more trust in the industry ( $\beta = 0.11$ ,  $p = .050$ , and  $\beta = 0.12$ ,  $p = .079$  respectively). Model 2 shows that there is no significant interaction effect of prior awareness with any of the other antecedents of joy, which suggests stable relationships between the antecedents and joy.

And indeed, people did become significantly prouder when they had prior awareness, when they had more trust in the industry, and when they saw the HFS as useful for local citizens. In addition to what was hypothesized, pride was also felt more strongly when people perceived less risk (and thus more safety). Pride was not significantly stronger when people perceived more positive environmental outcomes.

If pride only arises in response to what is seen as extraordinary achievement, then the perceived usefulness and safety of the HFS were considered extraordinary by the study participants, while the environmental benefits were not. Furthermore, it appears that people need to have some prior awareness, as well as some trust in those realizing the achievements, in order to feel a considerable level of pride. Overall, pride was explained by different factors – and by a larger variety of factors – than was joy. Model 2 shows that there is no significant interaction effect of prior awareness with any of the other included antecedents of pride, which suggests stable relationships between the antecedents and pride.

## 4. Discussion

Building on appraisal theory and insights from technology acceptance studies, this article has developed hypotheses for factors that influence the anger, fear, joy, and pride elicited by new energy projects,

and has tested them for the first publicly accessible hydrogen fuel station (HFS) project in the Netherlands. It has shown that perceived environmental outcomes, perceived risks, perceived usefulness for citizens living nearby, perceived procedural unfairness, perceived distributive unfairness, prior awareness, and trust in industry each explained one or more emotions in the expected directions.

The study shows that factors derived from appraisal theory can be applied in the context of technology acceptance, and that this can help explain specific emotions that energy projects give rise to. In turn, this paper contributes to appraisal theory by suggesting trust as an additional factor that explains emotions and that reflects the social context in which an event takes place. What's more, while appraisal theory studies are often limited to examining fairness in a very general way [41,19], the current study shows that perceived distributive fairness and perceived procedural fairness each play a distinct role in explaining the emotions that surround a local HFS project.

While this paper does have several limitations, these can be addressed in further studies. First, it is correlational in nature, and therefore causality cannot be ascertained. Experimental research will provide additional evidence about the suggested effects. Second, many emotions other than the ones included here – such as sadness, contempt, disgust, envy, guilt, and surprise – might also be relevant in the context of energy technology acceptance and could provide a more complete picture of the salient emotions. Third, appraisals other than the ones included here – such as perceived individual control over personal harm, the perceived extent to which scientists know all the risks of a technology [13], and others types of immorality besides unfairness [19] – might also play an important role. Fourth, goal significance or goal relevance was limited to measuring three perceived outcomes of the technology, while assuming that these are important to many people. Further research that combines measurements of goal importance with goal significance could shed fresh light on this matter. Fifth, the effects of prior awareness discussed here may have resulted both from novelty and from the fact that respondents obtained different information and had a variety of backgrounds. For instance, they likely differed in their level of interest in and ties to the local community, in their amount of news consumption or access to specific news sources, or in their interest in technologies in general. Further research could disentangle what underlies the effect of prior awareness on emotions and to what extent this is explained by novelty in particular.

Finally, the percentage of highly-educated respondents in the sample (that is, those having at least the equivalent of a BSc degree) was unrepresentatively high. However, since education was not significantly related to the dependent variables, and since the study focused on the relations among variables and not on the mean ratings of values, the overrepresentation of highly-educated respondents did not affect the value of the study (cf. [54]).

## 5. Recommendations

The three outcome considerations included here – the perceived outcomes for the environment, the perceived risks, and the perceived usefulness of the HFS for local citizens – all significantly explained the rating of one or more emotions. This suggests that all three potential outcomes are important to at least some of the respondents. Environmental responsibility and safety are also important ethical values, and usability is an important instrumental value, that philosophers of technology take into account when judging the acceptability of a technology (e.g. [55,56]). For ethical and practical reasons, decision-makers should therefore focus on these outcomes when designing, siting, and communicating about hydrogen technology.

Both the perceived procedural unfairness (measured by assessing the municipality's decision to grant a permit) and the perceived unfairness in the distribution of the costs, risks, and benefits of the hydrogen fuel station explained anger and fear. To avoid negative emotional responses, both types of unfairness must be taken into account

when managing a new technology. Moreover, fairness considerations help to determine the ethical acceptability of risky technologies [9].

Prior awareness cues stronger pride and joy and weaker fear than does prior unawareness. It is therefore possible that informing citizens ahead of time about a technological project will increase acceptance. However, this is not guaranteed, and the effect of such a tactic would need to be pretested. All the same, from an ethical point of view, it is crucial to inform people in a timely manner about new projects in their vicinity – especially when the risks are considerable or could be perceived as considerable [57,9].

Trust in industry has a significant positive effect on pride and a negative effect on fear. Taking actions that foster trust and that avoid sowing distrust can thus help to increase positive emotions and reduce negative emotions. Government and industry being trustworthy is also important from an ethical perspective when citizens are vulnerable to their actions [57]. Giving citizens or interest groups a voice in the decision-making process is one way to inspire trust in those who control the implementation of a technology [57,58].

The antecedents of emotions included in this study thus all involve practical as well as moral considerations that can and should be taken into account in the setup and execution of a technological project. One might think that project owners should focus mainly on reducing negative emotions in order to avoid public opposition. However, research has shown that positive emotions can also make people less likely to take action against an HFS and more likely to take action in favor of one [45]. Identifying, adjusting, and communicating about factors that reduce anger and fear, as well as factors that bring joy and pride, may thus strengthen support for and reduce resistance to a project. In any case, in communication, a good balance should always be struck between discussing positive and negative outcomes of a project. Otherwise citizens may be or feel manipulated, which can easily backfire [59].

In different contexts and cultures, different causes for emotions towards energy projects may be found. Therefore, in each individual case, emotions should not be taken at face value. Instead, considerations underlying these emotions should be probed and subsequently responded to (see also [10]).

## 6. Conclusions

The study has shown that perceived environmental effects, perceived risks, perceived usefulness for those living nearby, perceived distributive fairness, perceived procedural unfairness, prior awareness, and trust in those responsible for the technology are factors that significantly explain the anger, fear, joy, and/or pride inspired by a new hydrogen fuel station. Rather than merely resulting from ignorance and undermining the decision-making process, emotions can indicate relevant practical and even moral considerations that can and should be taken into account by policy-makers and industry managers who head up new energy projects.

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## References

- [1] S. Brunsting, M. De Best-Waldhober, C.F.J. Feenstra, T. Mikunda, Stakeholder participation practices and onshore CCS: lessons from the Dutch CCS case Barendrecht, *Energy Procedia* 4 (2011) 6376–6383.
- [2] C.F.J. Feenstra, T. Mikunda, S. Brunsting, What Happened in Barendrecht? Case Study on the Planned Onshore Carbon Dioxide Storage in Barendrecht, the Netherlands, ECN, Amsterdam, 2010, pp. 1–44.
- [3] N. Cass, G. Walker, Emotion and rationality: the characterisation and evaluation of opposition to renewable energy projects, *Emot. Space Soc.* 2 (2009) 62–69.
- [4] S. Roeser, Nuclear energy, risks and emotions, *Philos. Technol.* 24 (2011) 197–201.
- [5] A.R. Damasio, *Descartes' Error: Emotion, Reason and the Human Brain*, Avon, New York, 1994.
- [6] P. Slovic, M.L. Finucane, E. Peters, D.G. MacGregor, The affect heuristic, *Eur. J. Oper. Res.* 177 (3) (2007) 1333–1352.
- [7] P. Ellsworth, K.R. Scherer, Appraisal processes in emotion, in: R.J. Davidson, H.H. Goldsmith, K.R. Scherer (Eds.), *Handbook of Affective Sciences*, Oxford University Press, Oxford, 2003, pp. 572–595.
- [8] A. Moors, Flavors of appraisal theories of emotion, *Emot. Rev.* 6 (4) (2014) 303–307.
- [9] S. Roeser, The role of emotions in judging the moral acceptability of risks, *Saf. Sci.* 44 (8) (2006) 689–700.
- [10] S. Roeser, U. Pesch, An emotional deliberation approach to risk, *Sci. Technol. Hum. Values* (2016) 1–24.
- [11] N. Gupta, A.R.H. Fischer, L.J. Frewer, Socio-psychological determinants of public acceptance of technologies: a review, *Public Underst. Sci.* 21 (7) (2011) 782–795, <http://dx.doi.org/10.1177/0963662510392485>.
- [12] N.M.A. Huijts, E.J.E. Molin, L. Steg, Psychological factors influencing sustainable energy technology acceptance: a review-based comprehensive framework, *Renew. Sustain. Energy Rev.* 16 (1) (2012) 525–531, <http://dx.doi.org/10.1016/j.rser.2011.08.018>.
- [13] S. Dohle, C. Keller, M. Siegrist, Fear and anger: antecedents and consequences of emotional responses to mobile communication, *J. Risk Res.* 15 (4) (2012) 435–446.
- [14] G. Böhm, H.R. Pfister, Action tendencies and characteristics of environmental risks, *Acta Psychol.* 104 (2000) 317–337.
- [15] J.S. Lerner, D. Keltner, Beyond valence: toward a model of emotion-specific influences on judgment and choice, *Cogn. Emot.* 14 (4) (2000) 473–493.
- [16] J.S. Lerner, D. Keltner, Fear, anger, and risk, *J. Pers. Soc. Psychol.* 81 (1) (2001) 146–159.
- [17] P. Ekman, D. Cordaro, What is meant by calling emotions basic, *Emot. Rev.* 3 (4) (2011) 364–370.
- [18] J.L. Tracy, R.W. Robins, Show your pride. Evidence for a discrete emotion expression, *Psychol. Sci.* 15 (3) (2004) 194–197.
- [19] K.R. Scherer, Profiles of emotion-antecedent appraisal: testing theoretical predictions across cultures, *Cogn. Emot.* 11 (2) (1997) 113–150, <http://dx.doi.org/10.1080/026999397379962>.
- [20] J.L. Tracy, A.F. Shariff, J.T. Cheng, A naturalist's view of pride, *Emot. Rev.* 2 (2) (2010) 163–177.
- [21] L.A. Williams, D. DeSteno, Pride and perseverance: the motivational role of pride, *J. Pers. Soc. Psychol.* 94 (6) (2008) 1007–1017.
- [22] M. Ball, M. Wietschel, The future of hydrogen—opportunities and challenges, *Int. J. Hydrogen Energy* 34 (2) (2009) 615–627.
- [23] S. Dunn, Hydrogen futures: toward a sustainable energy system, *Int. J. Hydrogen Energy* 27 (3) (2002) 235–264.
- [24] C.-J. Winter, Hydrogen energy—abundant, efficient, clean: a debate over the energy-system-of-change, *Int. J. Hydrogen Energy* 34 (14, Suppl. 1) (2009) S1–S52.
- [25] M. Hodson, Case 20: London CUTE Hydrogen Fuelling Station, (2006).
- [26] J. Mumford, D. Gray, Reconciling conflicting interpretations of risk. A case study about the siting of a hazardous plant, *J. Commun. Manage.* 13 (2009) 233–249.
- [27] T. O'Garra, S. Mourato, P. Pearson, Investigating attitudes to hydrogen refuelling facilities and the social cost to local residents, *Energy Policy* 36 (6) (2008) 2074–2085.
- [28] NBC News (2004, 11-11-2004), Gas station first in the U.S. to pump hydrogen, Retrieved 1-6-2015, from [http://www.nbcnews.com/id/6460036/ns/us\\_news-environment/t/gas-station-first-us-pump-hydrogen/#.VWx6kHttKG4](http://www.nbcnews.com/id/6460036/ns/us_news-environment/t/gas-station-first-us-pump-hydrogen/#.VWx6kHttKG4).
- [29] De Gelderlander (2010, 3-12-2010), Eerste tankstation voor waterstof geopend in Arnhem, De Gelderlander, Retrieved from <http://www.gelderlander.nl/regio/arnhem-e-o/arnhem/eerste-tankstation-voor-waterstof-geopend-in-arnhem-1.2987788>.
- [30] R. Klazinga (2010, 3-12-2010), In een waterstofauto is voor passagiers geen plek meer, Trouw, Retrieved from <http://www.trouw.nl/tr/nl/4324/Nieuws/article/detail/1801198/2010/12/03/In-een-waterstofauto-is-voor-passagiers-geen-plek-meer.dhtml>.
- [31] NOS (2010, 3-12-2010), Eerste waterstof-tankstation in Nederland geopend, Retrieved from <http://nos.nl/artikel/202686-eerste-waterstof-tankstation-in-nederland-geopend.html>.
- [32] C. Keller, A. Bostrom, M. Kuttschreuter, L. Savadori, A. Spence, M. White, Bringing appraisal theory to environmental risk perception: a review of conceptual approaches of the past 40 years and suggestions for future research, *J. Risk Res.* 15 (3) (2012) 237–256.
- [33] G. Perlaviciute, L. Steg, The influence of values on energy alternatives, *Renew. Energy* 77 (2015) 259–267.
- [34] N.M.A. Huijts, B. Van Wee, The evaluation of hydrogen fuel stations by citizens: the interrelated effects of socio-demographic, spatial and psychological variables, *Int. J. Hydrogen Energy* 40 (33) (2015) 10367–10381.

- [35] E. Molin, A causal analysis of hydrogen acceptance, *Transp. Res. Rec.: J. Transp. Res. Board* 1941 (2005) 115–121.
- [36] F. Montijn-Dorgelo, C.J.H. Midden, The role of negative associations and trust in risk perception of new hydrogen systems, *J. Risk Res.* 11 (5) (2008) 659–671.
- [37] J. Mumford, D. Gray, Consumer engagement in alternative energy—can the regulators and suppliers be trusted? *Energy Policy* 38 (6) (2010) 2664–2671, <http://dx.doi.org/10.1016/j.enpol.2009.05.054>.
- [38] M. Ricci, P. Bellaby, R. Flynn, What do we know about public perceptions and acceptance of hydrogen? A critical review and new case study evidence, *Int. J. Hydrogen Energy* 33 (21) (2008) 5868–5880.
- [39] J.L. Zachariah-Wolff, K. Hemmes, Public acceptance of hydrogen in the Netherlands: two surveys that demystify public views on a hydrogen economy, *Bull. Sci. Technol. Soc.* 26 (2006) 339–345.
- [40] N. Frijda, P. Kuipers, E. Ter Schure, Relations among emotion, appraisal, and emotional action readiness, *J. Pers. Soc. Psychol.* 57 (2) (1989) 212–228.
- [41] G. Mikula, K.R. Scherer, U. Athenstaedt, The role of injustice in the elicitation of differential emotional reactions, *Pers. Soc. Psychol. Bull.* 24 (7) (1998) 769–783.
- [42] C. Gross, Community perspectives of wind energy in Australia: the application of a justice and community fairness framework to increase social acceptance, *Energy Policy* 35 (2007) 2727–2736.
- [43] P. Krutli, K. Tornblom, Wallimann-Helmer, M. Stauffacher, Distributive versus procedural justice in nuclear waste repository siting, in: B. Taebi, S. Roeser (Eds.), *The Ethics of Nuclear Energy. Risk, Justice and Democracy in the Post-Fukushima Era*, Cambridge University Press, Cambridge, 2015.
- [44] K. Van den Bos, J. Miedema, R. Vermunt, F. Zwenk, A self activation hypothesis of affective reactions to fair and unfair events: evidence for supraliminal and subliminal processes, *Soc. Justice Res.* 24 (2011) 6–24.
- [45] N.M.A. Huijts, E.J.E. Molin, B. Van Wee, Hydrogen fuel station acceptance: a structural equation model based on the technology acceptance framework, *J. Environ. Psychol.* 38 (2014) 153–166.
- [46] T. O'Garra, S. Mourato, P. Pearson, Analysing awareness and acceptability of hydrogen vehicles: a London case study, *Int. J. Hydrogen Energy* 30 (2005) 649–659.
- [47] G. Cvetkovich, P.L. Winter, The what, how and when of social reliance and co-operative risk management, in: M. Siegrist, T.C. Earle, H. Gutscher (Eds.), *Trust in Risk Management*, Earthscan, London, 2007.
- [48] D. De Cremer, T.R. Tyler, The effects of trust in authority and procedural fairness on cooperation, *J. Appl. Psychol.* 92 (3) (2007) 639–649.
- [49] T.R. Tyler, Trust in the twenty-first century, in: E. Shockley, T.M.S. Neal, L.M. Pytlikzillig, B.H. Bornstein (Eds.), *Interdisciplinary Perspectives on Trust: Towards Theoretical and Methodological Integration*, Springer International Publishing, 2016.
- [50] M. Siegrist, M. Cousin, H. Kastenhof, A. Wiek, Public acceptance of nano-technology foods and food packaging: the influence of affect and trust, *Appetite* 49 (2007) 459–466.
- [51] C.J.H. Midden, N.M.A. Huijts, The role of trust in the affective evaluation of novel risks: the case of CO<sub>2</sub> storage, *Risk Anal.* 29 (5) (2009) 743–751.
- [52] K.R. Scherer, Appraisal theory, in: T. Dalgleish, M. Power (Eds.), *Handbook of Cognition and Emotion*, Wiley, New York, NY, 1999, pp. 637–663.
- [53] K.R. Scherer, G. Ceschi, Lost luggage: a field study of emotion-antecedent appraisal, *Motiv. Emot.* 21 (3) (1997) 211–235.
- [54] G. Schuitema, L. Steg, M. van Kruining, When are transport pricing policies fair and acceptable? *Soc. Justice Res.* 24 (1) (2011) 66–84, <http://dx.doi.org/10.1007/s11211-011-0124-9>.
- [55] B. Taebi, A. Correljé, E. Cuppen, M. Dignum, U. Pesch, Responsible innovation as an endorsement of public values: the need for interdisciplinary research, *J. Responsible Innov.* 1 (1) (2014) 118–124.
- [56] M. Dignum, A. Correljé, E. Cuppen, U. Pesch, B. Taebi, Contested technologies and design for values: the case of shale gas, *Sci. Eng. Ethics* 22 (2016) 1171–1191.
- [57] M.R. Alfano, N.M.A. Huijts, Trust and distrust in institutions and governance. In: J. Simon (Ed.), *Handbook of Trust and Philosophy*, Routledge (forthcoming).
- [58] B.W. Terwel, F. Harinck, N. Ellemers, D.D.L. Daamen, Voice in political decision-making: the effect of group voice on perceived trustworthiness of decision makers and subsequent acceptance of decisions, *J. Exp. Psychol.: Appl.* 16 (2) (2010) 173–186.
- [59] G. De Vries, B.W. Terwel, N. Ellemers, Perceptions of manipulation and judgments of illegitimacy: pitfalls in the use of emphasis framing when communicating about CO<sub>2</sub> capture and storage, *Environ. Commun.* 10 (2016) 206–226.
- [60] K.R. Scherer, What are emotions? How can they be measured? *Social Sci. Inf.* 44 (4) (2005) 695–729.