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Promoting energy sources as environmentally friendly: does it increase public acceptability?

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Abstract

Environmental frames are widely used in an effort to increase public support for energy sources in the sustainable energy transition. Research suggests that environmental frames are most effective when they are congruent with people's biospheric values. Yet, this value-congruence account has been mainly tested for promoting behaviors, policies or products that have clear environmental benefits. But what if they do not? For example, what if energy sources are promoted as green but are not seen as such by the public? We extend the value-congruence account by proposing that besides the congruence between the frames and biospheric values, it is important to consider how much the products themselves are congruent with environmental frames and biospheric values. We tested this novel value-frame-product account by evaluating the effectiveness of environmental frames (versus financial frames) on the acceptability of energy sources that are typically seen as high, moderate, and low in environmental friendliness, and depending on how strongly people endorse biospheric values. Overall, the results supported none of the congruence accounts, suggesting that matching frames (and products) with people's values might be less effective in enhancing acceptability of products than previously thought. Instead, environmental framing increased the acceptability of all energy sources, independent of people's biospheric values and the perceived environmental friendliness of those energy sources. Moreover, highly environmentally friendly energy sources were more acceptable and evaluated more positively, especially among people who strongly endorsed biospheric values. We discuss the theoretical and practical implications of our study.

1. Introduction

Energy production from fossil fuels is a major contributor to global CO_2 emissions; a transition to more sustainable energy systems is therefore urgently needed [1, 2]. Various energy sources have been proposed for a sustainable energy transition. These include renewable energy sources, such as solar and wind energy, as well as non-renewable energy sources that emit relatively little CO_2 in comparison with (other) fossil fuels, such as natural gas and nuclear energy. The environmental benefits of such energy sources are being widely communicated via environmental frames, often assuming that this would increase public support for these energy sources [3–5]. Especially, it is expected that environmental frames will increase public acceptability among people who find environmental benefits important.

Noteworthy, not only renewable energy sources but also non-renewable energy sources, such as natural gas, are commonly framed as having environmental benefits (e.g., 'Thanks to natural gas, the air up here is cleaner', powerpastimpossible.org). However, while the environmental benefits of renewable energy sources may be

evident for people and thus emphasizing them might increase public support, this might not be the case for non-renewable energy sources. Indeed, while renewable energy sources, such as solar and wind energy, are generally perceived as environmentally friendly by the public [6, 7], people seem to be more skeptical about the environmental benefits of non-renewable energy sources. Nuclear power, for example, is often touted as environmentally friendly because it emits less CO_2 than fossil fuels for energy generation [8]. However, the public generally perceives nuclear energy as less environmentally friendly than renewable energy sources [9], and only a minority believes that nuclear energy could help to combat climate change [10]. Similarly, although natural gas is promoted as a relatively clean fossil fuel because it emits less CO_2 than oil and coal [11, 12], people do not perceive it as very environmentally friendly [13].

Thus, some energy sources are more likely to be perceived as environmentally friendly than others, even if all are promoted as such. The question is whether and how the extent to which people perceived energy sources as environmentally friendly influences the effectiveness of environmental frames. The present study addresses this question by exploring to what extent emphasizing the environmental benefits of energy sources that vary in the degree to which they are perceived as environmentally friendly can increase public support.

1.1. Value-congruent framing: aligning frames with biospheric values

The effects of environmental frames on public acceptability of energy sources may depend on people's values. Values are relatively stable, object-unspecific, and chronically-activated general goals that motivate and guide evaluations and behavior across different contexts [14–17]. The extent to which people endorse different values influences how they evaluate different characteristics of energy sources and which sources they find acceptable [18–20]. In particular, individuals focus on the implications of energy sources for their core values, which, in turn, influences their evaluations and acceptability judgements [18, 21]. That is, individuals evaluate more positively and are more willing to accept energy sources that they perceive as having positive implications for their important values [17, 22]. Conversely, people evaluate more negatively and are less willing to accept energy sources that they perceive as threatening their important values.

While different values (i.e., egoistic, hedonic, altruistic, and biospheric) can shape evaluations and acceptability of energy sources, biospheric values in particular seem most relevant for evaluations and acceptability of energy sources that are promoted via environmental frames. Strong biospheric values refer to valuing nature and the environment, and people who strongly endorse these values consider particularly the consequences of energy sources for nature and the environment important ([18]). In line with this, evidence suggests that framing environmental information in line with people's biospheric values—a strategy often referred to as value-congruent framing—might increase the effectiveness of frames. For instance, once informed about the negative environmental impacts of street lighting, people with strong biospheric values favored low (versus high) levels of street lighting [23]. Similarly, information about the negative environmental consequences of bottled water increased people's intentions to avoid bottled water and their support for policies to reduce the use of bottled water, provided that people strongly endorsed biospheric values [24]. Such value-matching appeals also increased acceptability of congestion charges aimed to reduce automobile traffic [25]. Further, research also suggest that environmental framing is more convincing than other types of framing (e.g., financial) for people who strongly endorse biospheric values. For example, the more people prioritized biospheric over egoistic values, the more they asked for tips on how to save paper after being told that saving paper is good for the environment versus that it is good for saving money [26] (for similar findings using factors closely related to biospheric values such as environmental concern and political ideology, see [27, 28]).

Noteworthy, all these studies promoted behaviors, products, and policies that are rather unambiguously seen as good for the environment (e.g., saving paper, using less plastic, renewable energy policies). As such, these behaviors, products, and policies are congruent with biospheric values and emphasizing this congruence makes the frames more convincing for those who strongly endorse these values. However, as mentioned earlier, sometimes the behaviors, products, and policies that are promoted with environmental frames may not be seen as very environmentally friendly, as for example non-renewable energy sources such as natural gas or nuclear energy. We know little about how environmental frames works for such products. Yet it is critical to address this question, since many different energy sources are being advocated for the sustainable energy transition.

1.2. Value-frame-product congruence: aligning frames, biospheric values, *and* products

We argue that it is important to consider not only the value-frame congruence, as done so far, but also the value-frame-product congruence. Specifically, not only the framing needs to match people's values, but also the product itself might need to match the framing and the values. For instance, if an energy source is not perceived as environmentally friendly to begin with, there might be a mismatch between environmental frames, peoples' biospheric values, and the energy source. Therefore, although stressing the environmental benefits of an energy source might in principle speak to people who strongly care about the environment, such frames may not be

effective if the promoted energy source is not seen as environmentally friendly. As such, environmental frames may not always be the best strategy to increase public acceptability of energy sources, even if the target audience strongly endorse biospheric values.

There is some initial, indirect evidence in line with the value-frame-product congruence account. People with stronger biospheric values did not evaluate natural gas more positively when it was promoted as a (relatively) sustainable energy source [13]. Yet, the stronger their biospheric values, the more positively people evaluated two gas innovations, biogas and power-to-gas, which may be seen as more environmentally friendly because they do not rely on fossil fuels. However, the frames for biogas and power-to-gas were not manipulated in this study, hence we do not know whether environmental frames would have been effective for those energy sources. Moreover, for natural gas, only environmental frames were used, with no control condition to judge the effectiveness of those frames. Finally, we can only speculate that people perceived biogas and power-to-gas as more environmentally friendly than natural gas—and therefore more congruent with people's biospheric values—as this was not measured in the study.

In the present work, we seek to solve these methodological shortcomings and build from this indirect evidence by providing a formal test of our value-frame-product account. Based on the above-mentioned reasoning, we hypothesize that the stronger their biospheric values, the more acceptable people will evaluate energy sources promoted with environmental frames, but only if these energy sources are perceived as environmentally friendly—compared to those perceived as less environmentally friendly.

1.3. Overview of the present study

To test the value-frame-product congruence account, in the current study we examine the impact of environmental frames on the acceptability of different energy sources that vary in how environmentally friendly they are typically perceived. We test whether matching values, frames, *and* products, is indeed important to enhance the acceptability of the promoted energy sources. We additionally study how framing and values influence the perceived different types of impacts of energy sources (e.g., on economy, public health). Specifically, values may have far-reaching effects and bias or '*color*' perceptions of impacts of energy sources that are not even very relevant for those particular values (e.g., economic impact for biospheric values) [18].

We first conducted a pilot study designed to evaluate people's beliefs about how environmentally friendly different energy sources are, hereinafter called typically perceived environmental friendliness. Based on the results, we selected energy sources that are typically perceived as high, moderate, and low in environmental friendliness. Then, we conducted an online experiment in which we systematically varied the framing of these energy sources and tested the effects of people's biospheric values, the framing, and the level of typically perceived environmental friendliness of the energy source on acceptability ratings and the perceived impacts of energy sources. In the following sections, we present the methods and results of the pilot study followed by the methods and results of the main experimental study.

2. Pilot study

2.1. Method: participants and procedure

Prolific, an online platform for data collection, was used to recruit seventy Dutch participants (67.14% were male; $M_{age} = 27.41$ years, $SD_{age} = 6.97$). After providing informed consent, participants were instructed to read short descriptions of seven energy sources, presented in random order, and asked to rate them in terms of perceived environmental friendliness (i.e., to what extent do you think X energy is environmentally friendly?; *Not at all* = 1 to 7 = *Very much*). [4] The descriptions of energy sources were brief (one sentence; see Annex 1 available online at stacks.iop.org/ERC/3/115004/mmedia), and focused only on how the energy is produced (e.g., solar energy is generated from heat and light of the Sun; nuclear energy is generated from the heat obtained by the fission of uranium atoms; wind energy is generated by using wind and air flows). [5] We avoided words that might influence perceived environmental friendliness (e.g., combustion; burn). After having rated all the energy sources, participants provided some demographic information (i.e., age, sex), and were thanked for their participation.

[4] We did not include energy sources commonly seen as very environmentally unfriendly (i.e., oil and coal) as they were intended to be used as reference points in the frames used in the main study. Furthermore, very environmentally unfriendly energy sources were likely to lead to floor effects.

[5] Please note that the pilot study, as well as, the main study were conducted in Dutch. The materials are provided both in Dutch and English in the supplement.

Table 1. Results of one-way repeated measures ANOVA and contrast analyses for perceived environmental friendliness of different energy sources (Pilot study).

Energy source	*M*	*SD*	Post-hoc comparisons[a]
Solar energy	6.24	.89	> natural gas, biomass, nuclear energy, geothermal energy
Hydro energy	6.20	.87	> natural gas, biomass, nuclear energy, geothermal energy
Wind energy	6.13	.79	> natural gas, biomass, nuclear energy, geothermal energy
Geothermal energy	5.27	1.32	< wind energy, solar energy, hydro energy / >natural gas, biomass, nuclear energy
Nuclear energy	4.40	1.97	< wind energy, solar energy, hydro energy, geothermal energy / >natural gas
Biomass	4.13	1.61	< wind energy, solar energy, hydro energy, geothermal energy / >natural gas
Natural gas	2.39	1.28	< wind energy, solar energy, hydro energy, biomass, nuclear energy, geothermal energy

Note: Overall ANOVA: $F(6, 414) = 89.57, p < .001, \eta_p^2 = .56$.

> Perceived as more environmentally friendly than, < perceived as less environmentally friendly than. All mean differences between the mentioned energy sources are significant at $p < .05$ in post-hoc analysis. Energy sources that do not differ significantly from the reference source are not mentioned.

[a] Results hold when applying a stricter criterion for post-hoc comparisons (i.e., Bonferroni correction).

2.2. Results and discussion

A one-way repeated measures ANOVA showed that the typically perceived environmental friendliness varied significantly between the energy sources, $F(6, 414) = 89.57, p < .001, \eta_p^2 = .56$. As observed in table 1, solar energy, hydro energy, and wind energy were perceived as more environmentally friendly than all other energy sources (all $ps < 0.05$), and their ratings did not differ from each other (all ps = n.s.). These energy sources were followed by geothermal energy which was perceived as more environmentally friendly than nuclear energy, $p = .003$, biomass, $p < .001$, and natural gas, $p < 0.01$. Finally, biomass and nuclear energy did not differ from each other, $p = .40$, and were both rated as more environmentally friendly than natural gas (both $ps < .001$).

Based on these results, solar energy, biomass, and natural gas were selected to represent energy sources that are typically perceived as high, moderate and low in environmental friendliness, respectively.

3. Main study

3.1. Method

3.1.1. Participants

Participants were recruited through Prolific and were people who live in the Netherlands and are fluent in Dutch. A power analysis was conducted in G*Power for sample size estimation [29], using an alpha of .05, a power of .90, and an estimation of a small-to-medium effect size for the relevant three-way interaction ($f = 0.20$; [23]). The projected sample size needed to detect the expected three-way interaction was 156. However, as our intended analytical strategy relied on linear mixed models (that usually involve the estimation of more parameters than approaches that do not involve random terms; [30]), we aimed for a larger sample size and used relevant literature as a reference point (e.g., $N = 266$ in [24]; $N = 360$ in [27]). We collected 550 participants, of which six failed to provide a correct answer to an attention-check question and were excluded from the analyses. Hence, the final sample consisted of 544 participants (57.4% males, 41.5% females and 1.2% chose 'other' or preferred not to say; $M_{age} = 28.27$ years, $SD_{age} = 9.19$ years).

3.1.2. Design and procedure

We employed a mixed 2 (Frame: environmental versus financial—between-subjects) × 3 (Typically perceived environmental friendliness: high versus moderate versus low—within-subjects) design and included biospheric values as a continuous predictor. Study materials, analyses syntax, data, and pre-registered hypotheses are available on the OSF: osf.io/9r4a7.

After providing informed consent, participants were told that they would participate in a study consisting of two parts. In the first part, participants' values were assessed. In the second part, participants read brief descriptions of three different energy sources (i.e., natural gas, biomass, and solar energy). Half of the participants were randomly assigned to read descriptions of the three energy sources that emphasized their environmental benefits (environmental frame condition; e.g., 'Solar energy has a relatively low impact on the environment and it is a sustainable energy source that will not run out'), while the other half was presented with descriptions of the same energy sources but emphasizing their financial benefits (financial frame condition; e.g., 'People who generate their own solar energy can save thousands of euros in the long run'; see Annex 2 for the full text used in the framing conditions). The presentation order of the three energy sources was randomized. Participants were asked to rate each energy source in terms of its acceptability and its impact on the economy, employment rates, public health, and the environment. Then, participants provided some demographic

information (i.e., sex, age, educational level and household income), and responded to a simple recall task designed to screen out inattentive responses. Finally, participants were debriefed and thanked for their participation.

3.1.3. Measures

Biospheric values. People's values were measured with a brief value scale [31]. The scale contains 16 items that measure egoistic, altruistic, hedonic and biospheric values. Biospheric values were assessed with four items: 'respecting the Earth', 'unity with nature', 'protecting the environment', and 'preventing pollution'. Participants rated each of these values on a 9-point scale ranging from −1 *opposed to my principles*, 0 *not important* to 7 *extremely important*. The biospheric values scale ($M = 4.55$, $SD = 1.37$) showed good internal consistency ($\alpha = .85$), as did the scales for the other values (egoistic values $\alpha = .76$, altruistic values $\alpha = .76$, and hedonic values $\alpha = .82$; these values were not used in the current study as they are not relevant for our hypotheses).

Acceptability of energy sources. We measured acceptability of the three energy sources using four 7-point semantic differential scales ranging from −3 to 3. Participants were asked to indicate to what extent they thought the different energy sources were: *very unacceptable* to *very acceptable*, *very bad* to *very good*, *very negative* to *very positive*, and *very unnecessary* to *very necessary* [32]; the internal consistency was good for all energy sources (Cronbach's α varied from .88 to .94).

Perceived impact of the energy sources. For exploratory purposes, participants were asked to evaluate the energy sources in terms of (1) environmental impact, (2) economic impact, (3) impact on public health, and (4) impact on employment rates (on a scale ranging from *very negative* = −3, to *very positive* = 3).

3.1.4. Data analysis

We followed Bates, Mächler [33] recommendations for model specification in linear mixed models. Acceptability scores were regressed on (1) biospheric values (centered), (2) framing condition (financial versus environmental), (3) typically perceived environmental friendliness of the energy source (high versus moderate versus low), and (4) all possible interactions between these variables. Random intercepts for participants and all possible random slopes for main effects and interactions were initially included as random terms in the model. Given that overly parameterized random effects decrease statistical power [34], random effects were sequentially removed—starting from higher order interactions—to arrive at more parsimonious (and converging) models. The same model specification procedure was used to explore the effects of the relevant factors on people's evaluations of the perceived impacts of energy sources. Details on the models-reduction processes can be found in Annex 3; summaries of random intercept and slope variances of each model are presented in Annex 4. We used the *lmer* function of the lme4 package [33] for R software environment for statistical computing (version 3.6.1; R Core Team, [35]). All models were initially fitted by restricted maximum likelihood (REML), and refitted by maximum likelihood (ML) whenever necessary (i.e., when comparing models via likelihood ratio tests). Satterthwaite approximations for degrees of freedom are reported[6].

3.2. Results

3.2.1. Acceptability of energy sources

We predicted that stronger endorsement of biospheric values would result in higher acceptability of energy sources promoted with environmental (versus financial) frames, and that this effect would occur particularly for the energy sources that are typically perceived as more, rather than less, environmentally friendly. The results did not support this three-way interaction implied by the value-frame-product congruence account, $F(2, 1080) = .53$, $p = .58$. There was also no interaction effect of framing and endorsement of biospheric values as suggested by the value-congruence framing account, $F(1, 243.72) = 1.17$, $p = .27$. However, we observed that energy sources that are typically perceived as more environmentally friendly were rated as more acceptable than those typically perceived as less environmentally friendly, $F(2, 1080) = 403.32$, $p < .001$. This effect was further qualified by an interaction with biospheric values, $F(2, 1080) = 4.63$, $p = .009$ (figure 1). As shown in table 2, simple slope comparisons revealed that, among people that strongly endorsed biospheric values (+1 *SD* above the mean), solar energy was more acceptable than biomass, $p < .001$, and natural gas, $p < .001$, whereas biomass was more acceptable than natural gas, $p < .001$. These differences in acceptability also emerged among people with weak biospheric values (−1 *SD* below the mean) but they were less pronounced (all $ps < .001$). In other words, people with both strong and weak biospheric values found energy sources typically perceived as more environmentally friendly more acceptable, but this effect was more pronounced among those with

[6] Due to the way that variance is partitioned in linear mixed models, there is currently no consensus on how standardized effect sizes for individual model terms (main effects and interactions) should be calculated [36]. Because of this and following general recommendations for reporting effect sizes [37], we report the unstandardized effect sizes (i.e., unstandardized beta coefficients) for all the models in the supplement (Annex 5).

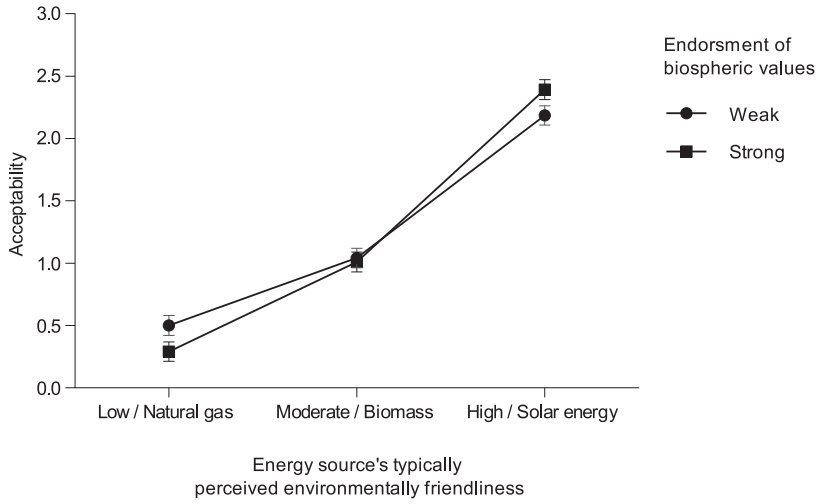

Figure 1. Acceptability ratings depending on energy sources' typically perceived environmental friendliness and endorsement of biospheric values.

Table 2. Simple effects of frame, typically perceived environmental friendliness and endorsement of biospheric values on acceptability ratings.

		Typically perceived environmental friendliness								
		Low / Natural gas			Moderate / Biomass			High / Solar energy		
		M	*SE*	95% CI	*M*	*SE*	CI	*M*	*SE*	95% CI
Biospheric values										
	Weak	.50	.07	0.34, 0.65	1.04	.07	0.88, 1.19	2.18	.07	2.03, 2.34
	Strong	.29	.07	0.13, 0.44	1.01	.07	0.85, 1.16	2.39	.07	2.23, 2.54
Frame										
	Financial	.23	.07	0.08, 0.39	.82	.07	0.67, 0.97	2.10	.07	1.95, 2.26
	Environmental	.55	.07	0.40, 0.70	1.22	.07	1.08, 1.37	2.47	.07	2.32, 2.61

stronger biospheric values. Finally, we observed a main effect of framing on acceptability of energy sources, $F(1, 519.54) = 23.44, p < .001$. For all types of energy sources and irrespective of the strength of people's biospheric values, environmental frames produced higher acceptability ratings compared to financial frames (table 2).

3.3. Perceived impacts of energy sources

We next examined the effects of biospheric values, framing, and the typically perceived environmental friendliness of energy sources, and their interactions, on the perceived impacts of energy sources for the economy (econ), employment rates (empl), public health (health), and the environment (env). These analyses were pre-registered as exploratory.

Results did not show a significant three-way interaction between biospheric values, framing, and the typically perceived environmental friendliness of energy sources on perceived impacts ($F_{econ}(2, 1080.17) = 1.72, p = .17$; $F_{empl}(2, 1080) = 2.09, p = .12$; $F_{health}(2, 1080) = .21, p = .80$; $F_{env}(2, 1080) = .27, p = .76$). Similarly, results did not show a two-way interaction between values and framing ($F_{econ}(1, 269.41) = 1.15, p = .28$; $F_{empl}(1, 540) = .04, p = .82$; $F_{health}(2, 1080) = 1.11, p = .73$; $F_{env}(1, 540) = .02, p = .88$). Instead, there was consistently a main effect of the typically perceived environmental friendliness of energy sources on their perceived impact on the economy, $F(2, 1080.17) = 45.18, p < .001$, employment rates, $F(2, 1080) = 27.51, p < .001$, public health, $F(2, 1080) = 656.51, p < .001$, and the environment, $F(2, 1080) = 687.46, p < .001$. Further, with the exception for the impact on the environment—where solar energy, $M = 2.25, SE = .05$, 95% CI $= 2.13, 2.36$, was perceived as having the lowest impact on the environment, followed by biomass, $M = .63, SE = .05$, 95% CI $= 0.51, 0.74, p < .001$, and natural gas, $M = -.59, SE = .05$, 95% CI $= -0.71, -0.48$, all ps $< .001$–, the effects of the typically perceived environmental friendliness of energy sources on all other perceived impacts were qualified by interactions with biospheric values, $F_{econ}(2, 1080.17) = 20.89, p < .001$; $F_{empl}(2, 1080) = 19.98, p < .001$; $F_{health}(2, 1080) = 9.24, p < .001$ (figure 2).

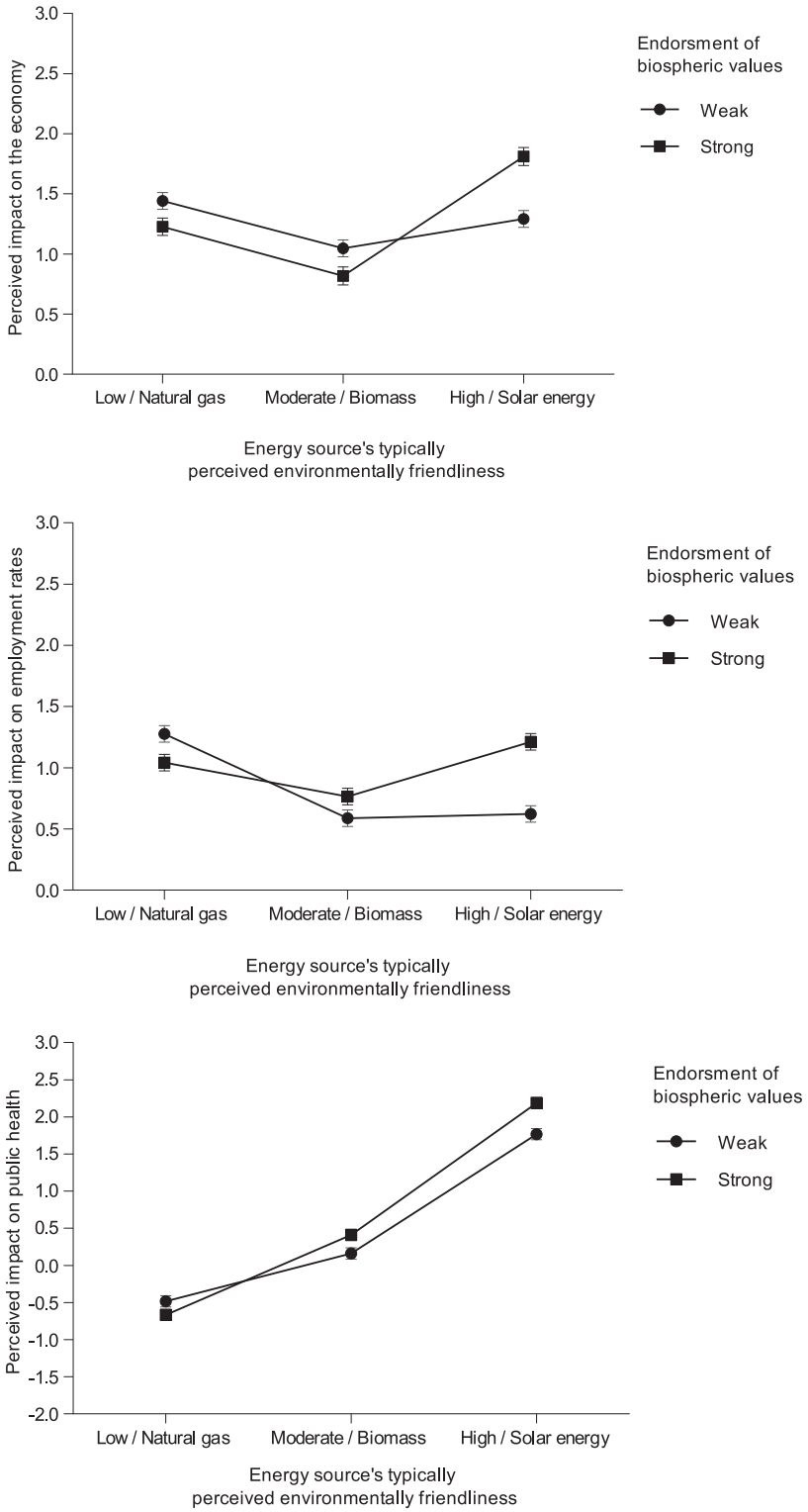

Figure 2. Ratings of perceived characteristics of energy sources depending on their typically perceived environmental friendliness and endorsement of biospheric values.

As seen in table 3, simple slope comparisons showed that, among people with strong biospheric values (+ 1 *SD* above the mean), solar energy was rated as having the most positive impact on the economy, compared to biomass, $p < .001$, and natural gas, $p < .001$, whereas natural gas was rated more positively than biomass, $p < .001$. Yet, among people with weak biospheric values (− 1 *SD* below the mean), there was no significant difference in the perceived economic impact of solar energy and natural gas, $p = .24$, while the two were still seen as having more positive impact on the economy than biomass, (both $ps < .001$).

Next, among people with strong biospheric values, solar energy and natural gas did not differ in the perceived impact on employment rates, $p = .15$, while both were perceived as having a more positive impact on

Table 3. Simple effects of frame, typically perceived environmental friendliness and endorsement of biospheric values on perceived impact ratings.

Perceived impact on			Typically perceived environmental friendliness								
			Low / Natural gas			Moderate / Biomass			High / Solar energy		
			M	*SE*	95% CI	*M*	*SE*	95% CI	*M*	*SE*	95% CI
	Biospheric values' endorsement										
		Weak	1.44	.07	1.30, 1.58	1.04	.07	0.90, 1.18	1.29	.07	1.15, 1.58
		Strong	1.22	.07	1.08, 1.37	.81	.07	0.67, 0.96	1.81	.07	1.66, 1.95
Economy											
	Frame										
		Financial	1.66	.07	1.52,1.80	1.13	.07	0.99, 1.27	1.60	.07	1.46, 1.74
		Environmental	1.00	.06	0.86, 1.13	.73	.06	0.59, 0.86	1.49	.06	1.36, 1.63
	Biospheric values' endorsement										
		Weak	1.27	.06	1.14, 1.41	.58	.06	0.45, 0.72	.62	.06	0.48, 0.75
		Strong	1.04	.06	0.90, 1.17	.76	.06	0.63, 0.90	1.21	.06	1.07, 1.34
Employment rates											
	Frame										
		Financial	1.54	.06	1.40, 1.67	.75	.06	0.62, 0.89	.86	.06	0.72, 1.00
		Environmental	.77	.06	0.64, 0.90	.59	.06	0.46, 0.72	.96	.06	0.83, 1.09
	Biospheric values' endorsement										
		Weak	−.48	.07	−0.63, −0.33	.16	.07	0.01, 0.31	1.76	.07	1.61, 1.91
		Strong	−.66	.07	−0.81, −0.51	.41	.07	0.26, 0.56	2.18	.07	2.03, 2.33
Public health											
	Frame										
		Financial	−.66	.07	−0.81, −0.51	.06	.07	−0.09, 0.21	1.88	.07	1.73, 2.03
		Environmental	−.48	.07	−0.63, −0.34	0.51	.07	0.36, 0.65	2.06	.07	1.92, 2.21
	Biospheric values' endorsement										
		Weak	−.55	.08	−0.71, −0.38	.69	.08	0.53, 0.85	2.24	.08	2.07, 2.40
		Strong	−.64	.08	−0.80, −0.47	.57	.08	0.40, 0.73	2.26	.08	2.09, 2.42
The environment											
	Frame										
		Financial	−.97	.08	−1.13, −0.80	.41	.08	0.25, 0.58	2.14	.08	1.97, 2.31
		Environmental	−.22	.08	−0.37, −0.06	.84	.08	0.68, 1.00	2.35	.08	2.20, 2.51

employment rates than biomass ($p < .001$ and $p = .007$, respectively). Yet, people with weak biospheric values not only rated the impact of natural gas on employment rates more positively than that of biomass, $p <. 001$, but also more positively than solar energy, $p < .001$. Biomass and solar energy ratings, in turn, did not differ from each other, $p = .92$.

Finally, among people with strong biospheric values, solar energy was perceived as having a more positive impact on public health than biomass, $p < .001$, and natural gas, $p < .001$, and biomass, in turn, was perceived more positively than natural gas, $p < .001$. Among people with weak biospheric values, these differences also emerged but were less pronounced (all $ps < .001$).

To summarize, results showed that people with stronger—compared to weaker—biospheric values evaluated the impact of solar energy on financial matters (i.e., impact on the economy, employment rates) more favorably. While solar energy was evaluated as having a more positive impact on the economy than natural gas among people with stronger biospheric values, evaluations of natural gas and solar energy did not differ among those with weaker biospheric values. Similarly, among people with stronger biospheric values, solar energy was perceived as positive as natural gas in terms of its impact on employment rates. Yet, among people with weaker biospheric values, the impact of natural gas on employment rates was evaluated more favorably than solar energy. Regarding non-financial matters (i.e., impact on public health, the environment), solar energy, and to a lesser degree, biomass, were perceived more positively than natural gas both among people with relatively strong and weak biospheric values.

Results also showed a consistent main effect of framing on the perceived impact of the energy sources on the economy, $F(1, 515.12) = 37.43, p < .001$, employment rates, $F(1, 540) = 20.89, p < .001$, public health, $F(1, 540) = 15.54, p < .001$, and the environment, $F(1, 540) = 36.82, p < .001$. Further, with the exception of the main effect of framing on the perceived impact on public health—where environmental framing, $M = .69$, $SE = .04$, 95% CI = 0.60, 0.79, produced more positive evaluations than financial framing, $M = .42$, $SE = .04$, 95% CI = 0.33, 0.52,—the effects of framing on all other perceived impacts were qualified by interactions with typically perceived environmental friendliness of the energy sources ($F_{\text{econ}}(2, 1080.17) = 8.79, p < .001$; $F_{\text{empl}}(2, 1080) = 23.37, p < .001$; $F_{\text{env}}(2, 1080) = 6.13, p = .002$; figure 3).

Specifically, as seen in table 3, environmental (versus financial) frames led to less positive evaluations of the economic impact of natural gas, $p < .001$, and biomass, $p < .001$, while it did not affect the perceived economic impact of solar energy, $p = .27$. Similarly, environmental (versus financial) frames led to less positive evaluations of the impact of natural gas on employment rates, $p < .001$, while they did not affect the perceived impact on employment rates of biomass, $p = .089$, and solar energy, $p = .29$. Finally, environmental (versus financial) frames led to more positive evaluations of perceived environmental impact of natural gas, $p < .001$, and biomass, $p < .001$, while they did not affect the perceived environmental impact of solar energy, $p = .068$.

Thus, overall, environmental (versus financial) frames produced more negative evaluations of the economic impact of natural gas and biomass, but not of solar energy. Also, they led to more negative evaluations of the impacts on employment rates of natural gas, but not of biomass and solar energy. Finally, environmental (versus financial) frames increased positive evaluations of the environmental impact of natural gas and biomass, but not of solar energy.

4. Discussion

Previous literature on value-congruent framing has shown that stressing the environmental benefits of energy sources can enhance public support, especially among people who strongly care about the environment (i.e., those who strongly endorse biospheric values; [21–23]). Yet, matching frames with people's biospheric values has so far mostly been proven effective for policies or products that have clear environmental benefits. We argued that such frames may be less effective in promoting policies and products that have not such clear environmental benefits. Particularly, we proposed a value-frame-product congruence account, implying that also the product itself needs to be congruent with the framing and people's biospheric values. We tested this novel account by evaluating the effects of biospheric values and framing on the acceptability of energy sources that varied in terms of how environmentally friendly they are typically perceived to be. Overall, results did not support either of the congruence accounts. Instead, results showed that environmental framing increased the acceptability of all types of energy sources no matter people's biospheric values, and the relationship between biospheric values and acceptability of energy sources depended on how environmentally friendly people perceived the sources to be. In the following, we discuss these and other results in detail.

4.1. Value-frame congruence and value-frame-product congruence

We expected that among people with strong biospheric values, energy sources promoted with environmental frames would be more acceptable, but only if these energy sources were typically seen as environmentally friendly relative to those seen as less environmentally friendly. We did not find support for this value-frame-product account, nor for the value-frame congruence account suggested in previous literature [23, 24, 26].

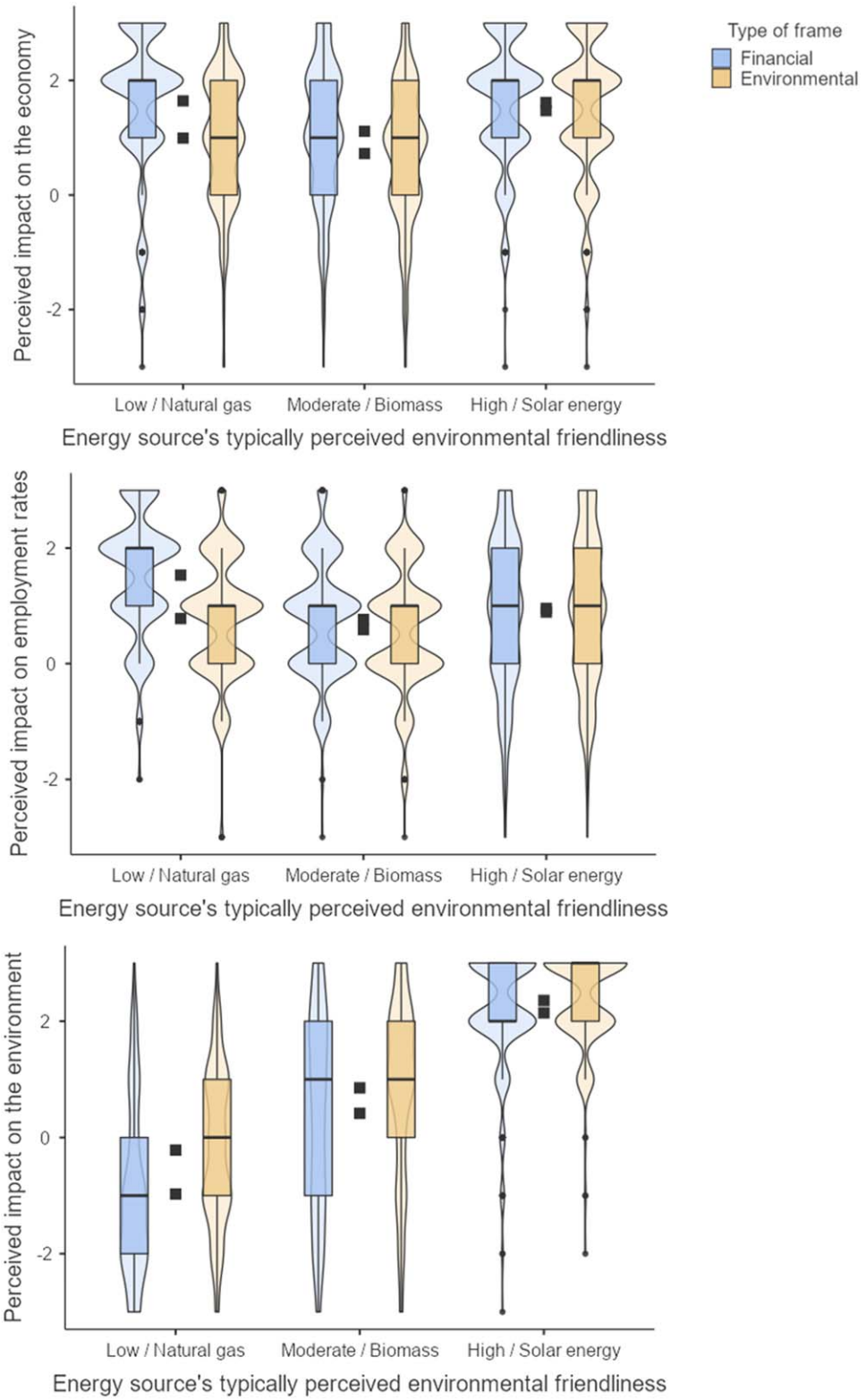

Figure 3. Violin plots for perceived impact ratings depending on energy sources' typically perceived environmental friendliness and frames. In each violin plot, the horizontal line indicates the median, the painted box indicates the interquartile range of the data, the shaded area indicates the density of the data, the squared dots indicate the means and the small dots indicate outliers.

Current results seem to suggest that matching frames with people's values might be less effective in enhancing acceptability of products than previously thought, or at least not equally effective in different contexts. For instance, recent work on the effect of environmental frames on curtailment behavior (i.e., 'living with less') suggests that pro-environmental frames did not lead to more curtailment, not even among participants who strongly endorsed biospheric values [38]. That being said, our results do indicate that biospheric values, frames, and types of products each play a relevant role in influencing acceptability of energy sources.

4.1.1. Two paths to public support? Value-product congruence and environmental framing

Our findings rather support a value-product congruence account. Specifically, our results suggest that energy sources typically perceived as more environmentally friendly (e.g., solar energy) were more acceptable than those typically perceived as less environmentally friendly (e.g., natural gas). Although this occurred among both people with strong and weak biospheric values, the effect was more pronounced among people with strong biospheric values. While this result suggests that, in our sample, people had a strong preference for solar energy relative to energy sources that are considered as less environmentally friendly (i.e., biomass and natural gas), it also suggests that caring for the environment is likely to intensify this preference. On the other hand, and aligned with previous research (cf [13]), our findings also imply that energy sources that are not typically perceived to be environmentally friendly are likely to be considered less acceptable, especially by people who strongly endorse biospheric values. Importantly, extending from previous work, in the current study we directly assessed how different energy sources are perceived in terms of their environmental consequences rather than just assuming what people might expect from them. Moreover, we tested the effects of environmental framing by contrasting them with another common framing strategy (i.e. financial framing).

Regarding framing effects on public acceptability, our results show that, compared to financial framing, environmental framing can be a more effective strategy to increase public support for energy sources, irrespective of the energy source and people's biospheric values. This finding aligns with previous work indicating that environmental frames tend to be more effective in motivating pro-environmental behavior than alternative frames [24, 39, 40]. Importantly, however, our findings extend previous studies by showing that environmental frames may not only motivate people to behave in sustainable ways, but also enhance the acceptability of products that have environmental consequences, such as energy sources. Moreover, our results suggest that environmental framing is likely to enhance public support even when these products are not seen as very environmentally friendly (e.g., natural gas). From a practical point of view, this implies that policy makers aiming to increase acceptability of energy sources could rely on environmental frames, which are likely to increase acceptability of different energy sources—even those that are considered to be relatively less environmentally friendly. This potentially opens opportunities for promoting energy sources that are not necessarily seen as most environmentally friendly, but that may be (temporarily) needed to support the energy transition by backing up renewable energy sources in meeting energy demands [41]. That being said, whether environmental frames can enhance acceptability of energy sources that are typically seen as environmentally harmful, such as oil and coal, is yet to be studied.

4.1.2. Effects on perceived impacts of energy sources

Stronger endorsement of biospheric values was not only related with higher acceptability of energy sources that were typically perceived as more (versus less) environmentally friendly, but also with more positive evaluations of the perceived various impacts of these energy sources. Indeed, in line with previous literature [18], people's biospheric values seemed to color the perceptions of different impacts of energy sources, including not only the impacts most relevant for these values (e.g., on the environment), but also other impacts (e.g., on the economy). People who strongly endorsed biospheric values evaluated solar energy more positively than biomass—and in some cases, than natural gas—on a range of impacts, including for example, the impact on the environment and on public health. In contrast, people with weak biospheric values evaluated solar energy less positively or only as positive as natural gas, at least regarding its impacts on the economy and employment. These results are consistent with the idea that values may have far-reaching effects and guide various evaluations [14, 15]. Yet, our results suggest that for these overly positive effects of biospheric values to occur, energy sources need to be seen as highly environmentally friendly to begin with, rather than just moderately or not environmentally friendly. Indeed, although people who strongly endorsed biospheric values evaluated biomass more positively than natural gas in terms of its impact on public health, impacts of biomass on the economy and on employment rates were rated less positively than those of natural gas, both among people with weak and strong biospheric values. As such, it seems that, while biospheric values might help to paint a positive perception of the impacts of energy sources that are highly beneficial for the environment (e.g., solar energy), they might not necessarily affect perceptions of energy sources that are just moderately environmentally friendly (e.g., biomass).

Regarding environmental framing, our findings showed that, although emphasizing the environmental benefits of energy sources enhanced their acceptability, it did not necessarily lead people to evaluate them more positively in terms of other impacts. Indeed, environmental framing—compared to financial framing, even led to less positive evaluations of natural gas—and in some cases, of biomass—with regard to impact on the economy and employment rates. Interestingly, however, environmental framing did lead to more perceived positive impact of these energy sources on public health. Moreover, it seems that environmental framing has a limited effect when the energy source is already perceived as environmentally friendly to begin with. Indeed, the perceived impact of solar energy on the economy, employment rates, and the environment did not differ depending on the frames. One potential explanation for this could be that most people already see solar energy very positively, causing a ceiling effect that prevents the additional value of environmental framing.

4.1.3. Limitations and future developments

The three energy sources used to test our predictions—solar energy, biomass, and natural gas—were all likely familiar to the public. It is unclear whether a similar pattern of results would emerge for other, particularly less known energy sources. People might have not yet formed expectations about the environmental benefits of, for example, macro-algae-based energy; future studies could explore the effects of biospheric values and environmental framing on a broader range of energy sources, including relatively novel sources.

We selected solar energy, biomass, and natural gas because they seem to represent energy sources that are typically perceived as high, moderate and low in environmental friendliness. This categorization, however, was based on a Dutch sample, and although the sample was similar to the one used for the main study, a different categorization might emerge among other samples. Future studies could examine whether similar perceptions are found among other samples, for example from different cultures and regions.

Furthermore, although the contents of frames were designed to contain a similar amount of arguments across experimental conditions (environmental versus financial) and for different energy sources, we did not pilot these descriptions to evaluate whether their arguments were equally persuasive. Future developments could build from this and evaluate argument strength of the different descriptions.

Finally, although our results indicate that environmental frames lead to higher acceptability ratings than financial frames, our design does not allow us to test whether this effect derives from environmental frames increasing acceptability or financial frames decreasing it. Future studies could further explore this effect by comparing both environmental and financial frames to a control condition where no benefits are mentioned. Moreover, the current study only used financial and environmental frames to promote the energy sources. Future research could test whether similar results would be found when using other types of frames such as social frames.

4.1.4. Conclusion

Overall, our study suggests that strong endorsement of biospheric values can enhance positive perceptions and the acceptability of energy sources, provided that people perceive them as being highly environmentally friendly. Also, our findings suggest that framing the environmental benefits of energy sources, as compared to framing their financial benefits, is an effective strategy to increase their acceptability, independent of people's biospheric values and whether the sources are perceived as environmentally friendly to begin with.

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Data availability statement

The data that support the findings of this study are openly available at the following URL: osf.io/9r4a7

Ethics statement

The research protocol of the present research has been approved by the Ethical Committee of Psychology at the Heymans Institute for Psychological Research of the University of Groningen.

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