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Research Article

Public Familiarity with Geothermal Energy on the North American West Coast

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Abstract

The 2013 Pacific Coast Action Plan on Climate and Energy signed by the Governors of Oregon, California, and Washington and the Premier of British Columbia, launched a broadly announced public commitment to reduce greenhouse gas emissions through multiple strategies. Those strategies include the development and increased use of renewable energy sources. The initiative recognized that citizens are both a central component to abating greenhouse gas emissions with regard to their energy use behaviors, and are important participants in the public policymaking process at both provincial/state and local levels of government. The study reported here examines public familiarity with geothermal energy, and the information sources used by the public to inform themselves about renewable energy technologies such as geothermal energy. The research results are based on surveys of randomly selected households conducted throughout the region.

Keywords

Geothermal energy; public familiarity with geothermal energy; societal acceptance; American West

1. Introduction

Concerns over climate change and energy independence give special importance to the non-fossil fuels in the energy mix. Advances in technological capabilities and a substantial cost reduction of renewables further facilitate the use of these energy sources. In addition, various federal and state policy provisions have advanced non-fossil energy development in the U.S. Federal tax credits (including the Renewable Electricity Production Tax Credit and the Business Energy Investment Tax Credit) have contributed to the growth of renewable energy resources, including geothermal energy. Furthermore, in accordance with the Energy Policy Act of 2005, the Bureau of Land Management and the Forest Service issued a Memorandum of Understanding (MOU) in 2006 to advance coordination in the permitting process of geothermal energy projects on public lands. The MOU had the goal to reduce the lease application backlog by 90% in five years and established a shared database to track applications [1].

The American West Coast states (California, Oregon, and Washington) adopted substantial policy measures to increase the share of renewables in the energy mix. In 2013, the Governors of California, Oregon, and Washington and the Premier of British Columbia, signed the Pacific Coast Action Plan on Climate and Energy, aimed to coordinate regional efforts in making the energy system more sustainable [2]. In addition, California, Oregon, and Washington adopted ambitious Renewable Portfolio Standards mandating investor-owned electric utilities operating in each state to increase the share of renewable energy sources. According to the California's Renewable Portfolio Standard, the required level of renewables should reach 60% by 2030, and by 2045 100% of electricity should be generated using renewable and zero-carbon energy [3]. In Oregon, the Renewable Portfolio Standard requires 50% of electricity to come from renewables by 2040 [4]. In Washington, Senate Bill 5116, signed into law in 2019, requires 80% clean electricity by 2030 and 100% clean electricity by 2045 for the entire state [5].

If the state and federal targets are to be fulfilled, renewable energy resources, including geothermal energy, should be procured at a greater scale. Geothermal energy is a low-carbon energy resource and it provides a baseload energy supply, unlike intermittent solar and wind energy sources. Geological conditions of the American West make geothermal energy a promising resource. California has the greatest geothermal energy potential in the entire U.S. due to its location on the Pacific's "ring of fire" [6]. The central and southeastern parts of Oregon also possess great geothermal energy potential [7]. Additionally, in Washington, areas located in the Cascade Range have significant opportunities for geothermal energy development [8].

Geothermal energy can be used directly for heating and cooling as well as to produce electricity [9]. Direct use technologies are currently growing in application and include district heating, space heating and cooling with the use of heat pumps, agricultural purposes (*e.g.*, greenhouses), fish farming, milk pasteurization, and other purposes [9, 10]. Dry steam, flash steam, and binary cycle power plants generate electricity using geothermal power [9]. In 2018, geothermal energy accounted for 5.91% of California's total system power, with a total of 43 geothermal power plants with an installed capacity of 2,730 MW [6]. In Oregon, geothermal energy makes up less than 1% of Oregon's electricity generation, with a total of three geothermal power plants with an installed capacity of 33 MW [7]. To date, there are no geothermal energy projects operating in Washington.

Despite the great potential for geothermal energy development in the American West Coast states, this resource is not fully developed. The share of geothermal energy in the energy mix is much lower than the share of other renewables, such as wind and solar. Ali [11] notes that high upfront costs and certain technical challenges (e.g., low conversion efficiency) make this resource difficult to develop. In addition, some geothermal energy projects meet with a low level of social acceptance ascribed to concerns over water use, potential seismic activity caused by geothermal drilling, wildlife threats, and potential noise and visual impact [12, 13]. The contentious case of Newberry Crater Geothermal Energy Project in Oregon is an example of such controversies due to potential impacts on the local community and environment [2].

Scholars deem public acceptance essential for successful development of renewable energy [12, 14-17]. Social science studies examining public attitudes and community action toward proposed renewable energy projects have focused largely on wind energy [14, 18-25]. In contrast, examination of the societal acceptance of geothermal energy has received little attention from social science research [26], making the literature on the societal aspects of geothermal energy development scarce [27]. Despite this general dearth of studies, in the past decade researchers examined public familiarity with and attitudes toward geothermal energy in the Australian [12, 28, 29], Chilean [17, 30], Japanese [15], and Italian [27] contexts.

One of the important aspects of societal acceptance of geothermal energy is the level of public knowledge about this technology. Researchers highlight the overall low level of public familiarity with geothermal energy resources. Several Australian studies reported a low level of public knowledge about geothermal energy [29]. Otero [17] states that "geothermal energy is the least known, most ignored yet most reliable and abundant local renewable energy source in Chile." Dowd et al. [28] maintain that "across wider society there appears to be little knowledge or understanding of geothermal technology and its implications." Pellizzonne [27] found evidence of a low level of knowledge of geothermal energy in central Italy. Kubota [15] notes that the level of public knowledge in Japan about geothermal power and biomass is lower compared to public awareness of fossil fuel, nuclear, hydropower, solar, and wind power.

Previous studies examined the relationship between the level of familiarity with a technology and its societal acceptance. Hobman [31] and Devine-Wright [14] maintain that existing research has produced conflicting results whether the two phenomena have a certain relationship. Some scholars [29-34] state that public knowledge of an energy technology affects the social acceptance of that technology. In contrast, Ellis [35] contends that there is not a lot of evidence of any relationship between knowledge of renewable energy and its acceptance, and further suggests that opponents of wind energy, for instance, usually are well informed about it. Along these lines, Devine-Wright [14] asserts that "a deficit of technical understanding does not equate with an absence of personal meanings or beliefs associated with energy technologies." Moula [16] emphasizes that "there is limited evidence that more informed individuals are accepting renewable energy technologies."

Despite significant scholarly attention to the factors influencing public support of renewable energy, including geothermal energy, fewer studies have considered public familiarity as the dependent variable, and a systematic analysis of factors influencing the level of public familiarity with geothermal energy is missing in the existing literature. To address this knowledge gap, the current study examines factors associated with public familiarity with geothermal energy, and the information sources used by the public to inform themselves about it. The study results are based on surveys of randomly selected households conducted throughout the American West Coast states.

In summary, to expand the existing literature on the social aspects of geothermal energy, the current research has two central aims: 1) Provide knowledge on the level of public understanding of geothermal energy using a new research context (the American West Coast); 2) Provide a systematic analysis of factors associated with the level of public knowledge and information sources used. The study concludes with practical suggestions that policy makers and industry leaders can use to develop more effective communication strategies.

2. Materials and Methods

Given the nature of the questions in the survey and the protections in place to protect individual respondent's identities, the Oregon State University Institutional Research Board determined that the research was "exempt" and therefore did not require full board review.

2.1 Literature Review on Demographic and Value Determinants of Familiarity with Alternative Energy Sources

2.1.1 Sociodemographic Correlates of Familiarity

While familiarity with specific policy issues have been shown to enhance the ability of citizens to recognize and act on their values and interests, much research has documented a "knowledge gap" between persons of lower and higher socioeconomic status [36, 37]. Persons of lower socioeconomic status (SES) have been found to exhibit lower levels of familiarity with policy issues [2]. Many variables associated with SES—e.g., education and household income—have been found to be associated with policy awareness in Canada, Japan and the U.S. [36-38]. Age and gender also have been found to be important predictors of policy familiarity and knowledge, with older cohorts exhibiting higher levels of policy familiarity and knowledge when compared to younger cohorts, and men tending to have higher levels of policy familiarity with some policy issues when compared to women [36, 39].

If familiarity with geothermal energy technologies is deeply rooted in SES and demographic attributes alone, the prospects for increasing familiarity levels will be limited, due to the static nature of gender, age, and educational attainment. Those individuals with lower levels of familiarity with a technology, may be less able to protect and promote their interests than those with higher levels of familiarity [36].

2.1.2 Value and Belief Correlates of Familiarity

In addition to sociodemographic explanations for policy familiarity, some social scientists have articulated another explanation for familiarity levels that includes values and beliefs, such as the New Ecological Paradigm (NEP) index measuring the level of environmental concern, climate change beliefs, and citizen perceptions of energy scarcity [2, 38, 40, 41]. This body of literature suggests that even when controlling for sociodemographic factors, values and beliefs can exhibit independent effects [2, 41].

Previous studies reported that persons with pro-environmental values and beliefs tend to be more aware of the issues related to energy use [31]. Value attributes can lead to the acquisition of information by citizens irrespective of their SES and demographic characteristics. For example, knowledge-seeking and knowledge-holding is highest among individuals who see a particular stake in policy outcomes [42] and those who are strongly committed to their policy views [37]. This pattern can be explained by the theory of motivated cognition suggesting that people's information processing might be heuristic-driven, and that people emphasize information that is consistent with their own values and the values of their peers [31].

Thus, one might expect higher levels of familiarity with alternative energy technologies among those citizens who have strong environmental attitudes and/or who believe in human caused climate change. In a previous study examining the impact of values and policy-relevant knowledge on renewable energy support in Oregon and Washington, both values and knowledge variables were the most important predictors of support for alternative energy policies for public survey respondents [32].

2.1.3 Information Source Reliance and Familiarity with Technology

Much of the literature on information source reliance has found that U.S. citizens often use a variety of sources for policy information. According to national polls, the most widely used source of information is television (i.e., local and national news programs), even though there is much concern by critics about the reliability of the information provided [37]. In 2016, the Gallup Poll [43] found that 22% of U.S. respondents used television for their main source of news for current events, followed by 16% for the Internet, 5% for newspapers, and 2% for radio. In terms of specific television channels, 9% reported watching Fox News and 8% reported watching CNN. Only 1% of respondents each reported reading the national newspapers New York Times or the Wall Street Journal [43].

The newest source of information is the Internet, where the range of information sites is almost countless including the use of social media. The 2016 Gallup survey [43] found that 6% of respondents use Facebook/Twitter and social media in general for news about current events. While some Internet sites can be highly informative and useful, other sites may spread false and misleading information. As the Georgetown University Library cautions users, "Unlike similar information found in newspapers or television broadcasts, information available on the internet is not regulated for quality and accuracy [44]."

Beyond the accuracy of a given media outlet, public awareness of emerging technologies is shaped by how the media directs public attention to certain issues. Specifically, those issues that get a lot of media coverage have a greater chance to become part of the public debate [12]. Devine-Wright [14] notes that previous findings reported that television appeared to be the main source of information that the public relies on to learn about geothermal energy. Curran [45] distinguishes three types of media systems: 1) Public service television (Denmark and Finland) that provides more coverage of news and issues related to public affairs and thus might lead to a higher level of public knowledge about these issues; 2) The market model (U.S.) that in general provides less coverage of news related to public affairs, which might lead to a lower level of public knowledge about issues of public life, including climate and energy issues; 3) A 'dual' model (UK) that combines features of the two previous models. Romanach et al. [12] found that media coverage of the Australian Government's Clean Energy Plan in 2011-2012 was limited by state and regional newspapers, which implies that people who rely on television as a source of information for learning about energy issues, especially with the market television model, would have less of a chance to learn about geothermal energy.

2.2 Methods

In order to assess public familiarity with geothermal energy, a mailed survey with an additional link to an online option, was sent to random samples of over 1,400 households each in California, Oregon, and Washington in 2014. Samples were provided by a commercial research company that has exhaustive databases of households comprised of telephone directories, state departments of motor vehicles, and other household information sources. Dillman's [46] Tailored Design Method was used in questionnaire design and implementation. Each contacted household received the following request for participation: “If available, we would prefer the person, 18 years old or older, who most recently celebrated a birthday to complete the survey.” Three waves of the mail surveys were distributed, followed by a final telephone reminder if necessary. Survey response rates vary only marginally among the three states’ citizens, with the highest percentage in Oregon (51.5%), followed by 48.9% in Washington, and 48.3% for California. Given the nature of the questions in the survey and the protections in place to protect individual respondent’s identities, the Oregon State University Institutional Research Board determined that the research was “exempt” and therefore did not require full board review.

The binary nature of the dependent variable prompts the use of logistic regression (1=familiar and very familiar with geothermal energy; 0=not familiar and somewhat familiar). This estimator is unable to make claims about marginal changes in the independent and dependent variables; rather it predicts the probability of a certain outcome. We use logistic regression in this study to assess the probability of each independent variable having an impact on the dichotomous dependent variable (familiarity with geothermal energy).

We examine several factors associated with public familiarity with geothermal energy. First, we expect that individuals with higher educational attainment are more likely to be familiar with geothermal energy relative to individuals with lower educational attainment (Hypothesis 1). Second, we expect that individuals with higher income are more likely to be familiar with geothermal energy relative to individuals with lower income (Hypothesis 2). Third, we expect that men are more likely to be familiar with geothermal energy compared to women (Hypothesis 3). Fourth, we expect that elder individuals are likely to be more familiar with geothermal energy compared to younger individuals (Hypothesis 4). Fifth, we expect that people with higher environmental concern are more likely to be familiar with geothermal energy relative to individuals with lower environmental concern (Hypothesis 5). Sixth, we expect that people with higher concern over climate change are more likely to be familiar with geothermal energy relative to individuals with lower concern over climate change (Hypothesis 6). Finally, we expect that people with higher concern over energy scarcity are more likely to be familiar with geothermal energy relative to individuals with lower concern over energy scarcity (Hypothesis 7).

We also examine correlation between the level of public familiarity with geothermal energy and different information sources used to get knowledge about energy policy. Based on previous research on information use and knowledge of various energy sources [2], we expect that individuals who use public broadcasting, newspapers, and university information sources will be more familiar with geothermal energy when compared to those who use television and the internet for information (Hypothesis 8).

3. Results

3.1 Familiarity with Geothermal Energy

Table 1 shows the level of familiarity of respondents in California, Oregon, and Washington with geothermal energy. The level of public familiarity was overall consistent among respondents in all three states. In California, 27.9% of the respondents said they were 'familiar' or 'very familiar' with geothermal energy, 37.5% said they were 'somewhat familiar,' while over one-third of the respondents (34.6%) said they were 'not familiar' with geothermal energy. In Oregon and Washington, 25.6% and 26.5% of respondents, respectively, said they were 'familiar' or 'very familiar' with geothermal energy, 42% and 36.5% said they were 'somewhat familiar,' and over one-third of the respondents (32.5% and 37%) said they were 'not familiar.' Overall, the survey results suggest that the level of familiarity of the public with geothermal energy in California, Oregon, and Washington is low as over one-third of respondent have no knowledge about the technology.

Table 1 Familiarity with geothermal energy.

Question: How familiar are you with specific renewable energy technologies including biofuel, wind, solar, geothermal and wave energy? (Responses for geothermal energy provided below).

	California	**Oregon**	**Washington**
Not Familiar	34.6%	32.5%	37.0%
Somewhat Familiar	37.5%	42.0%	36.5%
Familiar	22.1%	21.5%	20.0%
Very Familiar	5.8%	4.0%	6.5%
N =	691	755	710

3.2 Correlates of Familiarity with Geothermal Energy

Table 2 provides the means for the study independent and control variables. The sample has a nearly even split across values of the independent variable *'Gender'* (51% females and 49% males in California, 50% females and 50% males Oregon, and 54% females and 46% males Washington). We also control for age – as observed in Table 2, values range from 18 to 91 years old, with the mean of 48 years old in California and 49 years old in Oregon and Washington. The independent variable *'Education'* was measured on the scale from 1 (Grade School) to 8 (Postgraduate/Professional Degree (e.g., MA, JD, etc.); the mean value for this independent variable in California is 5.32, in Oregon – 5.07, in Washington – 5.25 (Table 2). The independent variable 'Income' was measured on the scale from 1 (less than $10,000) to 8 ($200,000 or more), the mean value is 5.49 in California, 5.24 in Oregon, and 5.37 in Washington.

Table 2 also displays the means for variables that reflect respondents' environmental values and beliefs. On the scale from 1 (Strongly Disagree) to 5 (Strongly Agree), the mean value for a variable depicting respondents' perceptions of energy scarcity is 3.5 in California, 3.53 in Oregon, and 3.46 in Washington. The mean value for a New Ecological Paradigm Index, measured on the scale from 6 (Dominant Social Paradigm) to 30 (New Ecological Paradigm) is 21.21 in California, 21.30 in Oregon, and 21.07 in Washington. The binary variable measuring respondents' belief that the earth is getting warmer mostly because of human activity, such as burning fossil fuels, has the following frequency distribution: 41% of respondents in California (40% of respondents in Oregon and Washington) think that the earth is getting warmer mostly because of human activity such as burning fossil fuels.

Table 2 Independent and control variables.

Variable Name	**Variable Description**	**California** *Mean (s.d.)*	**Oregon** *Mean (s.d.)*	**Washington** *Mean (s.d.)*
Age	*Respondent Age in Years* [Range: 18 to 91 years]	47.99 (16.50) n=693	48.86 (16.28) n=754	48.80 (15.04) n=713
Gender	*Dummy Variable for Respondent Gender* 1= female, 0= male	.51 n=690	.50 n=755	.54 n=712
Education	*Formal Educational Attainment* 1=Grade School to 8=Postgraduate/Professional Degree (e.g., MA, JD, etc.)	5.32 (1.17) n=658	5.07 (1.27) n=749	5.25 (1.23) n=703
Income	*Annual income before taxes* 1=Less than $10,000 to 10=$200,000 or more	5.49 (2.24) n=658	5.24 (2.10) n=728	5.37 (2.11) n=684
Scarcity	*I am concerned that our country doesn't have enough energy resources.* 1=Strongly Disagree to 5=Strongly Agree	3.50 (1.39) n=688	3.53 (1.33) n=754	3.46 (1.34) n=211
NEP	*New Ecological Paradigm Index* 6=Dominant Social Paradigm to 30=New Ecological Paradigm (Cronbach's alpha=.830)	21.21 (5.20) n=690	21.30 (5.18) n=747	21.07 (5.33) n=709
Climate	*Believe that the earth is getting warmer mostly because of human activity such as burning fossil fuels.* 1=Yes, 0=Else	.41 n=693	.40 n=756	.40 n=715

The logistic regression results are presented in Table 3. In all three states women tend to be less familiar with geothermal energy than men ($p \leq .001$), which is consistent with the existing literature. Contrary to the previous studies, age and income seem to have no effect on the level of familiarity with geothermal energy. As predicted, education demonstrates a positive and significant association with the level of familiarity in California and Washington ($p \leq .001$), (although, there is a negative and statistically insignificant effect in Oregon).

Surprisingly, pro-environmental values (measured via New Ecological Paradigm Index) have no impact on the level of familiarity with geothermal energy. Only in Oregon, those who believe that the earth is getting warmer mostly because of human activity such as burning fossil fuels tend to have more knowledge about geothermal energy ($p \leq .001$). Contrary to our expectation, those who are concerned that the U.S. does not have enough energy resources tend to have less knowledge about geothermal energy (though this association is statistically significant only in California ($p \leq .001$).

Table 3 Logistic regression analysis of familiarity with geothermal energy[a].

	California *Coefficient* *(SE)*	**Oregon** *Coefficient* *(SE)*	**Washington** *Coefficient* *(SE)*
Age	.003	-.003	.012
	(.006)	(.006)	(.006)
Gender	-.480**	-.485**	-.915***
	(.195)	(.185)	(.200)
Education	.365***	-.018	.300***
	(.092)	(.073)	(.083)
Income	-.050	-.042	-.035
	(.043)	(.044)	(.045)
Scarcity	-.231***	-.122	-.031
	(.067)	(.067)	(.071)
NEP	.000	-.004	.000
	(.020)	(.020)	(.020)
Climate	.083	.657***	.246
	(.218)	(.201)	(.210)
Chi-square =	40.992***	21.454**	44.753***
Percent Explained=	71.8%	74.5%	73.3%
N =	638	715	658

[a] The dependent variable is: 1=Familiar and very familiar with geothermal energy; 0=Not familiar and somewhat familiar.

*$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

3.3 Information Source Use and Familiarity with Geothermal Energy

Table 4 presents the means for different information sources used by the respondents to learn about energy issues and policy. As shown in the table, television and the Internet are the most used information sources followed by public broadcasting, radio programs, and major newspapers, and utilities. Local sources of information such as local newspapers, local community leaders, and state elected officials tend to be used less by the public as a source of information to learn about energy issues and policy.

Table 4 Information source use for energy policy.

Question: We would like to know which of the following information sources you currently use or would use to learn more about (state's) energy situation and policy? Please circle the number of the frequency of your use.

		Never	Infrequently	Frequently	Very Frequently
		Percent	*Percent*	*Percent*	*Percent*
Television News Programs and Specials [N=2,155]	CA	8.9	25.7	43.3	22.2
	OR	5.7	25.5	43.4	25.5
	WA	4.6	27.5	46.5	21.3
Public Broadcasting [N=2,155]	CA	13.3	37.9	33.2	15.6
	OR	13.3	34.9	32.8	19.0
	WA	13.2	37.9	33.0	15.9
Radio Programs [N=2,152]	CA	24.9	33.6	31.7	9.7
	OR	22.7	37.1	28.7	11.4
	WA	20.4	36.9	30.7	12.0
Major Newspaper [N=2,152]	CA	17.4	36.5	27.1	19.0
	OR	13.6	30.3	33.1	23.0
	WA	14.8	33.4	34.6	17.2
Local Newspaper [N=2,150]	CA	25.3	37.4	25.3	12.1
	OR	21.2	39.0	26.0	13.7
	WA	21.6	38.6	28.1	11.7
Local Community Leaders [N=2,148]	CA	38.8	49.2	10.9	1.0
	OR	35.6	50.9	12.4	1.2
	WA	34.2	48.6	16.1	1.1
State Elected Officials [N=2,148]	CA	37.8	47.8	12.7	1.7
	OR	34.7	47.1	16.6	1.6
	WA	30.5	51.6	16.2	1.7
State Department of Energy [2,149]	CA	32.0	43.5	20.6	3.9
	OR	33.4	46.7	17.6	2.4
	WA	25.7	52.0	19.3	3.0
Universities and	CA	33.9	39.2	20.6	6.3

Colleges	OR	32.1	45.0	19.4	3.5
[N=2,149]	WA	28.5	46.5	20.9	4.1
Utilities	CA	13.9	45.3	32.4	8.4
[N=2,152]	OR	17.0	39.8	36.7	6.5
	WA	11.8	42.5	37.6	8.2
Environmental	CA	29.8	42.3	22.4	5.5
Groups	OR	29.8	41.3	20.8	8.1
[N=2,148]	WA	30.6	42.9	21.0	5.5
Information	CA	16.2	23.9	37.2	22.6
Available on the	OR	19.9	24.2	36.5	19.4
Internet	WA	16.4	25.3	36.9	21.3
[n=2,155]					

Table 5 displays correlations between information source and geothermal energy familiarity. People who rely on television as a source of information about energy policy, are less likely to obtain knowledge about geothermal energy (this result is statistically significant in California and Washington ($p \leq .001$), but not in Oregon). All other sources of information demonstrate positive correlations with the level of familiarity with geothermal energy in all three states, although are not always statistically significant (Table 5).

Table 5 Correlations between information source use and familiarity with geothermal energy.

	California	**Oregon**	**Washington**
	Tau b	*Tau b*	*Tau b*
Television news programs and specials	-.084**	-.023	-.94**
Public Broadcasting	.106***	.074*	.123***
Radio Programs	.085**	.033	.123***
Major Newspaper	.041	.048	.075*
Local Newspaper	.093**	.053	.053
Local Community Leaders	.099**	.025	.109***
State Elected Officials	.030	.013	.045
State Department of Energy	.058	.074*	.108***
Universities and Colleges	.164***	.145***	.117***
Utilities	.009	.023	.016
Environmental Groups	.121***	.104***	.112***
Information Available on the Internet	.187***	.206***	.119***

*$p \leq .05$; **$p \leq .01$; ***$p \leq .001$

Table 6 shows the relationship between the number of sources used by the respondents and the level of familiarity with geothermal energy. The results suggest that the more information sources participants use, the more familiar they are with geothermal energy.

Table 6 Number of information sources used and familiarity with geothermal energy.

	0 to 3 Sources	4 to 6 Sources	7 Plus Sources
California			
Not Familiar	45.9%	31.9%	25.4%
Somewhat Familiar	32.9%	40.3%	41.0%
Familiar	16.1%	21.4%	25.8%
Very Familiar	5.1%	6.4%	7.8%
N =	255	1,277	551
Chi-square =	30.04, p = .000		
Oregon			
Not Familiar	41.2%	30.6%	23.0%
Somewhat Familiar	34.9%	45.0%	47.8%
Familiar	21.6%	19.9%	24.2%
Very Familiar	2.4%	4.5%	5.0%
N =	255	331	161
Chi-square =	19.16, p = .004		
Washington			
Not Familiar	42.0%	37.4%	25.4%
Somewhat Familiar	36.5%	34.0%	43.0%
Familiar	18.3%	21.9%	19.6%
Very Familiar	3.2%	6.7%	12.0%
N =	219	329	142
Chi-square =	19.73, p = .002		

4. Discussion

In agreement with earlier studies, the survey results show that the level of public knowledge about geothermal energy technology is low among residents of the North American Coast states. As Figure 1 illustrates, about 34% of respondents indicated that they were 'not familiar' with geothermal energy and only about 5% of respondents considered themselves 'very familiar' with the technology. The fact that a significant portion of the public has little knowledge or understanding of geothermal technology might become a challenging factor in the process of engaging citizens in a conversation about potential geothermal energy development. The media is especially important in influencing public familiarity with geothermal energy because the general public tends to not actively search for information related to emerging technologies but is likely to receive this information from the media [12].

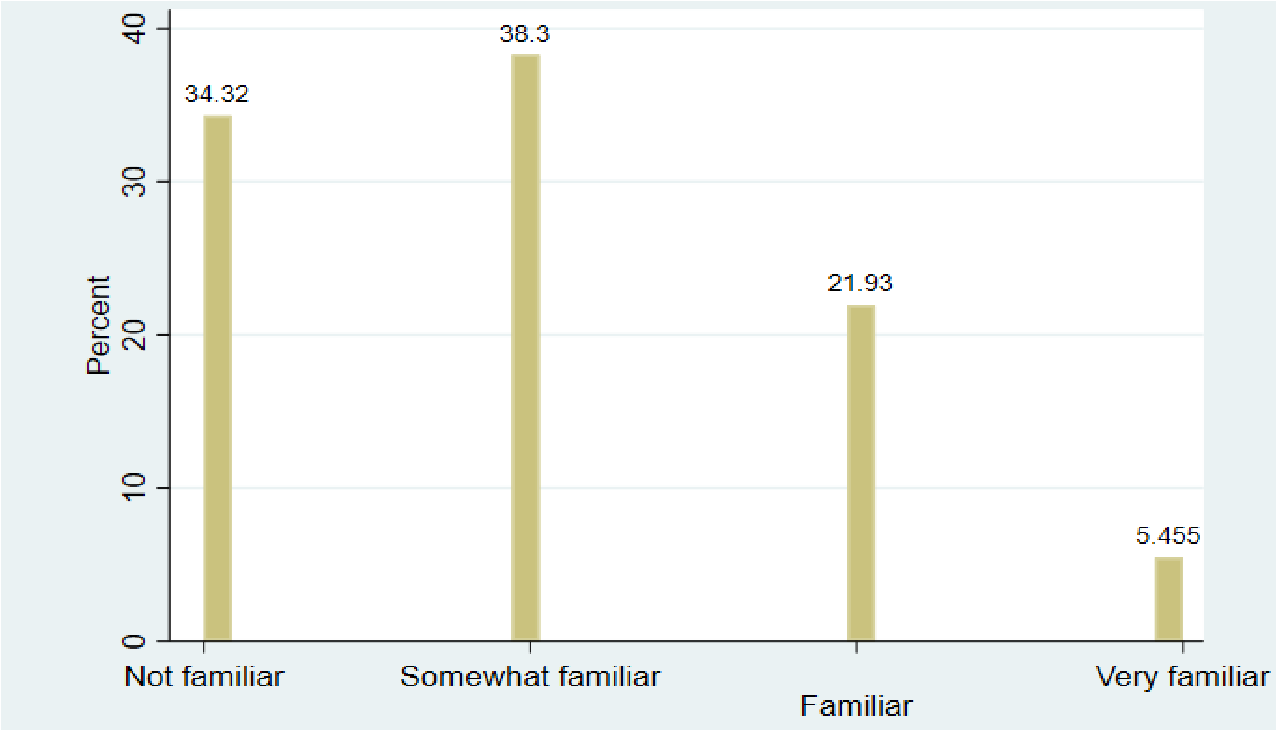

Figure 1 Degree of public familiarity with geothermal energy.

Although the public's familiarity with geothermal energy cannot guarantee its acceptance, it can help facilitate democratic discussions regarding the technology potential development. Pellizzone [47] maintains that "low levels of knowledge and high levels of uncertainty are a fertile ground for controversies." In consonance with this, Hobman [31] argues that public familiarity with renewable energy is a foundation for informed decision-making related to the future of the energy system. Therefore, policy makers and industry leaders should take measures to broaden knowledge of geothermal energy among diverse groups of the public. The results of the current study have implications for communicating information about geothermal energy.

Consistent with previous studies, familiarity with geothermal technology seems to be associated with gender, with men being more informed about the technology than women, as demonstrated in Figure 2. In addition, education demonstrates a positive association with the level of familiarity in California and Washington. The anticipated relationship between respondents' environmental values and beliefs and their familiarity with geothermal energy has not demonstrated statistical significance. Previous studies have found a positive correlation between people's pro-environmental values and their support for wind and solar energy but not for hydro or geothermal energy, suggesting that people with high environmental values might be less supportive of energy sources that have more physical environmental impact, in spite their renewable nature [29]. This pattern might also be present with people's familiarity with renewable energy sources.

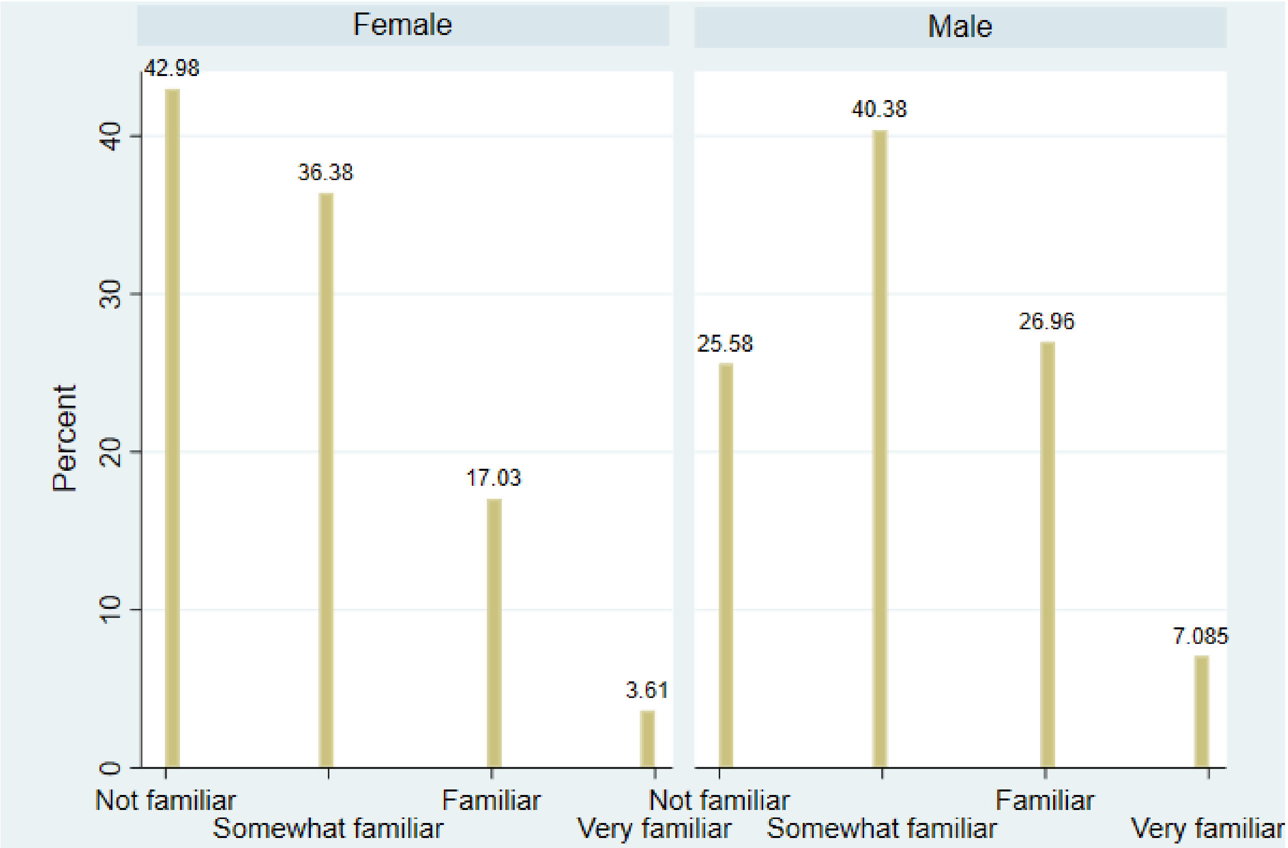

Figure 2 Degree of public familiarity with geothermal energy by gender.

Communication of information about geothermal energy should address the fact that certain societal groups tend to have a systematically lower level of knowledge of this technology. Thus, communication strategies might include appropriate message framing and utilize motivating strategies and provide supportive context for learning about geothermal technology [31]. The technical complexity of materials should vary depending on the audience. For instance, when providing information to the general public about geothermal energy, the complex technical component could be minimized and, instead, the notions of how geothermal energy might affect people's lives could be highlighted [17].

The sources of information people use to learn about energy issues and policy affect the level of their familiarity with geothermal energy. As illustrated in Figure 3, people who rely on television as a source of information, are less likely to be familiar with geothermal energy (this result is statistically significant in California and Washington, but not in Oregon). All other sources of information demonstrate positive correlations with the level of familiarity, although the impact is not always statistically significant. As Figure 4 indicates, the Internet appears to be an important source of information about geothermal energy, but its potential can be expanded with help of social media [17]. There is also a positive correlation between the number of sources respondents use to learn about energy policy and levels of familiarity with geothermal energy, therefore information dissemination should be diversified if possible.

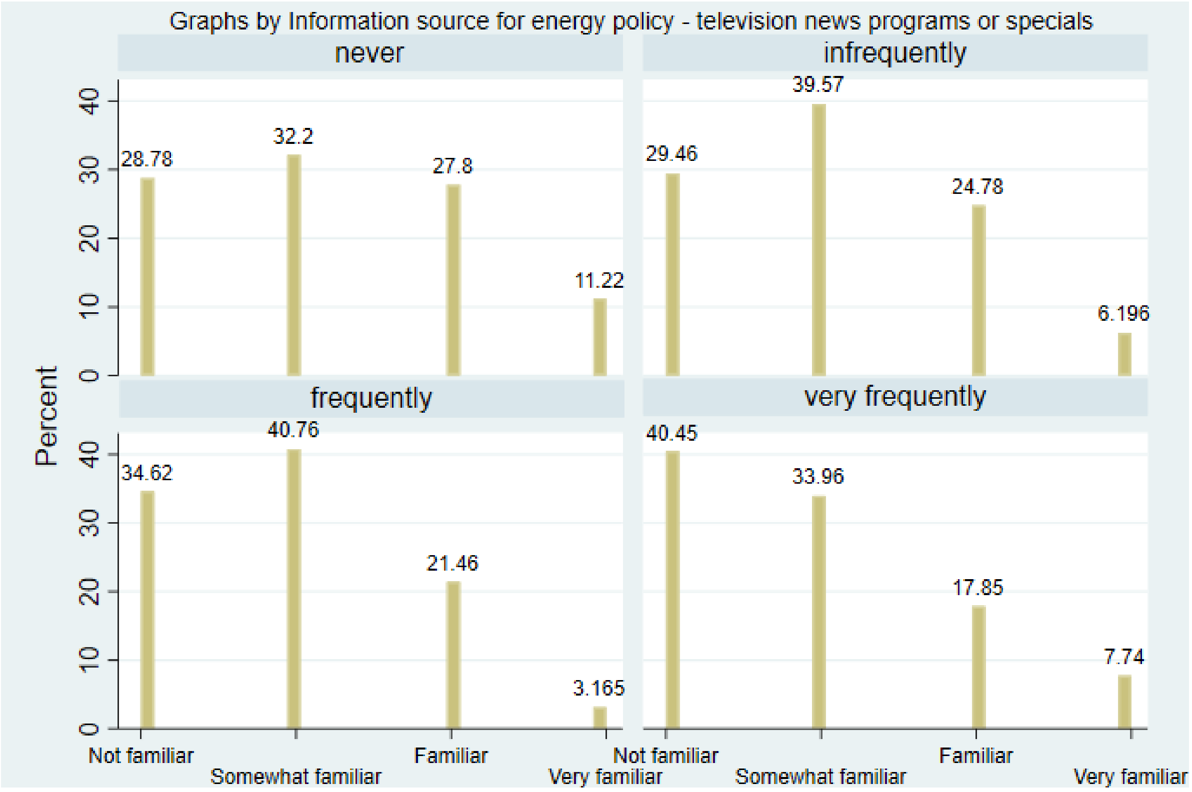

Figure 3 Degree of public familiarity with geothermal energy by information source for energy policy (television news programs and specials).

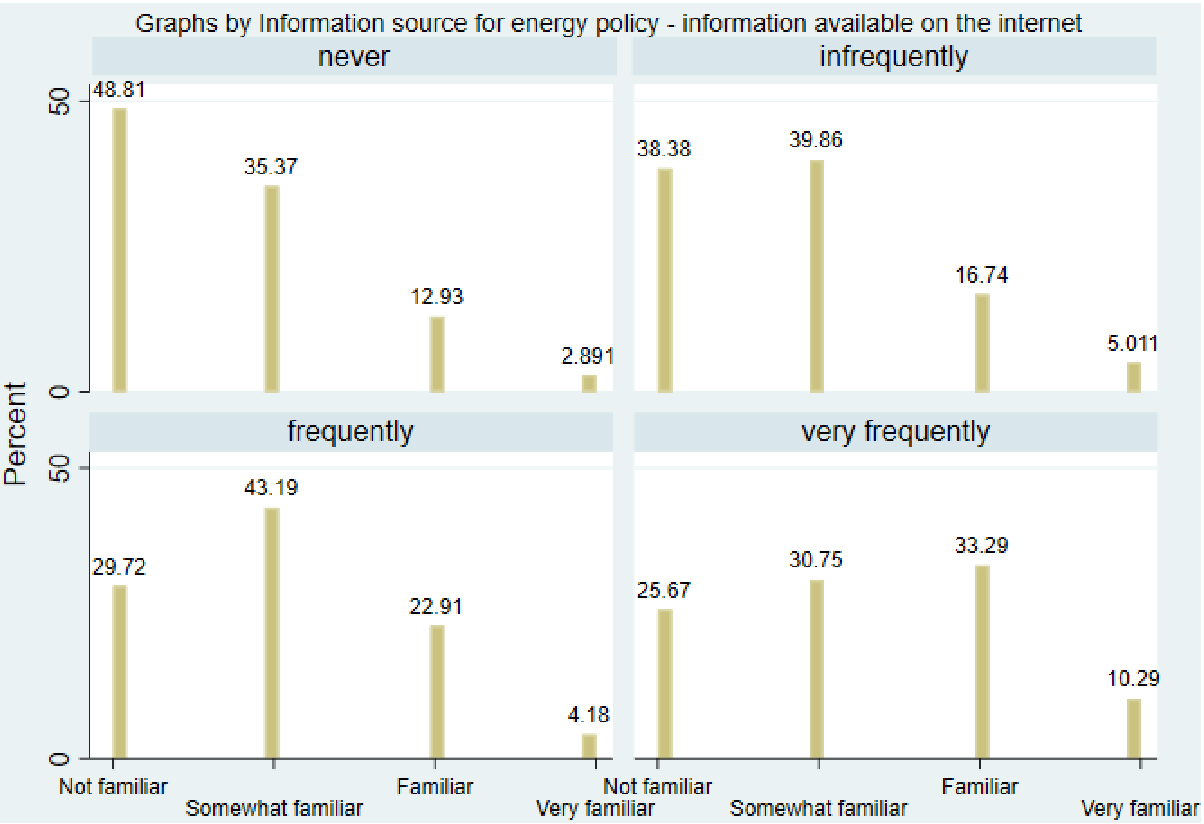

Figure 4 Degree of public familiarity with geothermal energy by information source for energy policy (information available on the Internet).

Devine-Wright [14] notes that previous research found that local newspapers have a great influence in rural areas. The current survey has not examined public familiarity with geothermal energy and the information sources used by the public to inform themselves about it in rural and urban areas, and future research should consider exploring this topic. Additionally, Hobman [31] found that the provision of information about costs and emission levels attributed to different energy sources, substantially alters public acceptance of these resources. Along these lines, Romanach et al. [12] notes that it is important to provide information about both potential risks and benefits of geothermal technology to the public. Therefore, future studies should consider examining factors that affect not just the overall level of public knowledge about geothermal energy but also the level of different types of knowledge (e.g., risks and benefits). In addition, Park and Ohm [33] and Pellizzone [47] argue that public attitudes toward geothermal energy can differ between cultures and countries. Therefore future research should examine factors influencing public familiarity with geothermal energy in other contexts (for example, in less democratic countries) that might reveal new theoretical insight.

5. Conclusions

The current study examined public familiarity with geothermal energy, and the information sources used by the public to inform themselves about renewable energy technologies such as geothermal energy. The research results are based on surveys of randomly selected households conducted in California, Oregon, and Washington. Results demonstrate that on average, women tend to be less familiar with geothermal energy than men, which is consistent with the existing literature. Contrary to the previous studies, age and income seem to have no effect on the level of familiarity with geothermal energy. As predicted, education demonstrates a positive association with the level of familiarity in California and Washington. Surprisingly, pro-environmental values did not demonstrate positive and statistically significant impacts on the level of familiarity with geothermal energy. Only in Oregon, those who believe that the earth is getting warmer mostly because of human activity such as burning fossil fuels tend have more knowledge about geothermal energy. The results also show that people who rely on television as a source of information, tend to be less familiar with geothermal energy (this result is statistically significant in California and Washington). Local sources of information (local newspapers, local community leaders, and state elected officials) appear to be less popular among the respondents as sources of information about energy issues and policy. In addition, the study finds a positive correlation between the number of sources respondents use to learn about energy policy and levels of familiarity with geothermal energy. Based on the survey results, the study provided several suggestions for policy makers and technology developers for creating more effective communication strategies regarding geothermal energy.

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Author Contributions

Conceptualization, B.S.S., A.K.; Methodology, B.S.S.; Analyses, A.K.

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Competing Interests

The authors have declared that no competing interests exist.

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