Students' Perceptions And Attitudes Towards Renewable Energy Sources

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Abstract

Renewable energies have attracted our attention in the last decades due to their rapid development and low costs. In Colombia, environmental and related professionals are required with skills to understand, become aware, commit, accept, adapt, and participate in this field in an informed and critical manner, articulating disciplinary knowledge with social, cultural, economic, and political issues. It is urgent to address these issues in programs of the environmental faculty of the Universidad Distrital Francisco José de Caldas from a perspective of education in renewable energies. This study aims to analyze the attitudes and perceptions of students toward renewable energies. The results show that the perception towards renewable energy sources is the one that determines the behavior; favorable attitudes towards them are also observed.

Keywords: Renewable energy education, non-conventional renewable energies, perceptions, and attitudes.

Introduction

The depletion of fossil energy resources and the effects on the environment due to their indiscriminate use has become a global problem (Jennings P. et al., 2001; Lovelock J., 2007; Ott, Aadu, et al.,

2018; Stephen E., 2013). The global energy crisis hits developing countries with a more significant impact; poor quality of life is associated with difficult access to quality and affordable energy (Pedro, J., 2010). The earth is a self-regulating living system. Therefore, we must think about the welfare of both the earth and humans; an effort must be made to avoid the consumption of fossil fuels so that cleaner and safer energies can replace them through an energy transition (Evans, Pritchard, 2014; Lienhoop, N., 2017; REN 21., 2019).

Likewise, according to different researchers, it is imperative to implement training programs oriented to Education in Non-Conventional Renewable Energies - EERNC, since the sector is developing rapidly and demands training programs aimed at all actors of society for its promotion and appropriation from a perspective of awareness, understanding, commitment, and participation with emerging renewable technologies (Andersen, N., 1986; Broman, L, 1994; GWEC, 2019). In Colombia, the need for an energy transition is being discussed; in the world, issues of utmost importance for citizenship are also being raised, such as energy sovereignty and the democratization of energy (Varo B., 2019).

Energy is of such importance that access to energy is focused on the Sustainable Development Goal - SDG 7, in three fundamental pillars, access to energy, renewable energy penetration – RE, and energy efficiency - EE. Renewable energy technologies - RETs provide a practical option for access to clean energy that decreases CO2 emissions, contributing significantly to climate change mitigation (IRENA, 2019; REN 21., 2019).

For several years there has been talking of a process of transition of energy sources to RE; there is an emphasis on investments in solar and wind farms; this additionally brings several aspects such as competitiveness and seeking to increase the efficiency of the sources, so that RE should not only be thought only from an ecological perspective, but also academic, economic, political, cultural, and social. Therefore, more knowledgeable professionals are required in the technologies associated with RE. A key element is to change their attitudes and habits. Thus, the primary objective of this paper is to examine the current position of students of the Faculty of the Environment towards RE sources as a starting point to adjust subsequent objectives and activities. In Colombia, Law 2099 of 2021 modifies and adds Law 1715 of 2014, which modernizes the current legislation and seeks to accelerate sustainable development through

the adoption of new sources of non-conventional renewable energy generation - NCRE, also promoting energy efficiency and sustainable mobility, thus partially reducing the gap in access to NCRE sources.

Literature review

The topic of NCRE is currently arousing great interest, and the literature is abundant and growing.

According to Alsabbagh Maha (2019), studies conducted in developed countries have mainly been done from qualitative research approaches to relatively small samples (Karjalainen & Ahvenniemi, 2019; Sommerfeld J. et al., 2017). On the other hand, in developing countries, the studies conducted used quantitative research approaches along with relatively large samples (Bashiri, A. & Alizadeh, S.H., 2018). However, some studies correspond to both types of countries that have used mixed research methods (Strazzera & Statzu, 2017; Ndebele (2020) in research conducted in New Zealand explored how the fossil fuel-dominated energy market could be combined with RE from consumers' perception (Ndebele, T., 2020).

According to a study conducted by the European Commission - EC, 2006, it was found that the citizens of the European Union believe that the NCREFs to be used in the coming decades will correspond to 80% supporting the use of solar energy, 71% wind energy, and 65% hydropower. Previous studies show citizens' positive perceptions and attitudes toward NCREFs (Bidwell D., 2016; Zyadin et al., 2014).

In other research, Stigka et al. (2014) state that socioeconomic characteristics, such as interest in environmental issues, knowledge of FERNC, and education, correlate with willingness to pay. Also, citizens in some developed countries, such as Sweden, possess greater environmental awareness and are more likely to accept RE (Cristina Ek, 2005). In the same sense, different studies affirm that citizens with strong environmental preferences are more likely to invest in technologies related to energy conservation (Kollmuss A. & Agyeman J., 2002). Wan Abdullah et al. (2018) consider that higher levels of awareness and knowledge can lead to increased acceptance and willingness toward NCREFs.

Methodology

This study aimed to know students' behavior about the FERNCs of the Faculty of the Environment of the Universidad Distrital Francisco José de Caldas and to identify the factors that influence their behavior.

Specifically, the main objective is to investigate students' awareness regarding FERNCs and determine which elements of their attitudes and perceptions influence and affect their behavior towards FERNCs. A five-point Likert-type survey assessed understanding, mood, and perception.

The statistical analysis was performed using Python through the implementation of different libraries, such as Pandas, for the case of the management and manipulation of the data obtained from the survey applied in Google Forms and from which an Excel file was obtained that stored the results of the study, 101 was the number of respondents, it has for each form a total of 35 columns corresponding to the number of specific questions referring to NCRE and another five questions correspond to a display of the date, The Numpy library was also used to manage the different numerical arrays that were developed as a result of the data engineering generated with Pandas when using and evaluating each column of the multiple questions created. Finally, an implementation of the Matplotlib library was used. pyplot library that allows the creation of graphs to add different styles of lines and diagrams, both circular and bar charts, for the respective analysis.

The sample corresponds to 101 students of Environmental Engineering, Environmental Management, Sanitary Engineering, Forestry Engineering, Topographic Engineering, Environmental Sanitation Technology, Topographic Surveying Technology, Environmental Management Technology, and Sports Administration. The survey was conducted between October 2021 and August 2022. A five-point Likert-type scale questionnaire was used, which was adapted from the one proposed by Djuric Vladimir et al. (2020) in the article "Analysis of public attitudes and perceptions towards renewable energy sources in Montenegro."

The hypothetical basic structural model contains three concepts: level of awareness (i.e., from an NCRE knowledge perspective), perception and attitude towards RE, and behavior towards RE.

The first group: the level of awareness of NCRE sources, was measured using ten variables. As presented in Table 1, the first variable is labeled A1 and shows the attention (knowledge) of NCRE projects in Colombia; the following statements seek to know if the respondent has some level of understanding. Variable A7 indicates the level of expertise about fossil fuels and their adverse environmental consequences. The

statement "Wind (for wind generation) is one of the most abundant sources of non-conventional renewable energy in Colombia," corresponding to variable A9, seeks to determine how much is known about wind energy as a source of NCRE and its importance for Colombia. Responses range from 1 (totally disagree or not necessary) to 5 (agree entirely or very important).

The second group comprises variables related to perceptions about renewable energy sources. They have been coded with 13 variables, shown in Table 1. They are labeled Q1 to Q13; with them, we wish to inquire regarding students' perceptions towards RE technologies, education, context, and environment. Responses range from 1 (totally disagree or not necessary) to 5 (agree entirely or very important).

Behavior/attitudes toward renewable energy, as a dependent variable in the model, was expressed through 12 variables (C1 through C12). Statement C1, "As a society, we should use less oil, coal, and natural gas to reduce environmental impacts on land, water, and air quality," through C12, seek to quantify the attitudes of our electrical engineering students toward NCREs. Table 1 provides basic measures of descriptive statistics as well as reliability analysis. Cronbach's Alpha has been calculated for the three groups of variables to ensure the validity of subsequent studies. Since all Cronbach's Alpha values are more significant than 0.7, the interrelationships of these groups of variables can be confidently examined further.

Table 1. Measurement of variables and descriptive statistics

Variable	Code	Observed variable	Range	Half	Standard Deviation	Cronbach's Alpha
Consciousness/Knowledge	A1	1. Do you agree with the development of non-conventional renewable energy projects in Colombia?	1-5	3.1700	1.01123	0.724
	A2	2. You believe that all types of devices should be regulated so that we have information about the energy efficiency of the devices.	1-5	3,4032	0,98173	
	A3	3. Should Colombia invest in the development of other projects similar to the Hidroituango hydroelectric plant?	1-5	3,4862	0,98642	

	A4	4. It would be good if the buildings were equipped with solar and/or wind energy systems.	1-5	2,0632	1,04462	
	A5	5. Do you know anything about the auctions won by EDP Renovaveis to generate wind energy in Guajira?	1-5	1,8617	0,95152	
	A6	6. Wind generation systems generate nuisances to the communities that live near them.	1-5	1.3202	0.46746	
	A7	7. Carbon dioxide from burning coal, oil and natural gas is partly causing global warming.	1-5	1,4822	0,50067	
	A8	8. Most of the electricity produced in Colombia comes mainly from hydroelectric power plants.	1-5	1,6087	0,48901	
	A9	9. Wind (for wind generation) is one of the most abundant non-conventional renewable energy sources in Colombia.	1-5	1,6285	0,48417	
	A10	10. The problem of environmental pollution is an issue that should be of concern to us.	1-5	1.3502	0.46543	
Perception	P1	11. The entire population of the world should behave in an environmentally friendly manner.	1-5	3.8656	1.07539	0.802
	P2	12. The adverse consequences of climate change affect Colombia's socio-political and economic context.	1-5	3.2174	1.27716	
	P3	13. A very important benefit of non-conventional renewable energies is their positive impact on quality of life.	1-5	4.1225	0.86190	
	P4	14. An important contribution of non-conventional renewable energies is their contribution to environmental protection.	1-5	4.4032	0.90606	
	P5	15. Non-conventional renewable energy projects generate economic development for the regions.	1-5	3.9447	0.87565	
	P6	16. A relevant aspect of non-conventional renewable energy technologies is that they promote sustainable development.	1-5	4,1660	0,86609	
	P7	17. The development of non-conventional renewable energy technologies and projects contributes to the creation of new jobs.	1-5	3,6324	0,99366	
	P8	18. A major consequence of non-conventional renewable energies is that it promotes the end of dependence on oil.	1-5	4.0553	0.94957	

	P9	19. Energy conservation (savings) is one way to contribute to mitigating the adverse effects of climate change.	1-5	3.3636	1.17943	
	P10	20. Promoting education courses on non-conventional renewable energies is an urgent need in Colombia.	1-2	3,5322	0,99246	
	P11	21. Colombia has the capacity to produce solar and/or wind energy technology.	1-5	3,6225	0,98353	
	P12	22. There are sufficient training courses for citizens in non-conventional renewable energies in Colombia.	1-5	3.3432	1.18441	
	P13	23. Education in non-conventional renewable energies for leaders and politicians is evident in Colombia's public energy policies.	1-5	3.9345	0.86961	
Behavior/Attitudes	C1	24. As a society, we should use less oil, coal and natural gas to reduce environmental impacts on land, water and air quality.	1-5	2.5889	0.71617	0.718
	C2	25. As a citizen I must be responsible and my behavior towards the environment must be respectful.	1-5	3.7273	1.19885	
	C3	26. It is my responsibility to conserve (save) energy by acting and taking proper care of our environment.	1-5	3.4625	1.13196	
	C4	27. If the utility offered you non-conventional renewable energy for your home at a higher initial price (for two years), would you be willing to accept it?	1-5	3.4585	1.17314	
	C5	28. If it were within your means to invest in generating your own energy, would you select any non-conventional renewable energy source(s)?	1-5	3.4032	1.29234	
	C6	29. It is very important that the chargers of cell phones and other devices be disconnected when not in use.	1-5	4.4348	0.91325	
	C7	30. We must take care of water sources, moorlands and water wealth in general.	1-5	4.1265	1.01566	
	C8	31. Would you be willing to participate and support non-conventional renewable energy projects in your community?	1-5	3,2925	1,21230	
	C9	32. We all need to recycle and properly dispose of our household waste.	1-5	4,3360	0,93953	

	C10	33. Would you like to take one or more training courses in non-conventional renewable energies?	1-5	3.8340	1.00993	
	C11	34. It would be better to buy an electric car paying a little more for it, than a more economical gasoline or diesel one.	1-5	4,3462	0,92752	
	C12	35. In your household (family), would you change the lighting system to LED or energy efficient lighting?	1-5	4.0263	1.01646	

Table 2. Results of estimating the correlation of the different variables - Behavior is the dependent variable.

Causal relationship	Non-normalized Path coefficient	Standard error	P	Normalized Path coefficient
Comport. ← Consciousness/Knowledge	2.430	0.931	0.009***	0.207
Comportamiento ← Perception		1.725	0.623	0.006***
0.328				
Perception ← Consciousness/Knowledge		0.169	0.084	0.043**
0.076				
Behavior ← C1	1.000	–	–	0.106
Behavior ← C2	7.281	2.480	0.003***	0.460
Behavior ← C3	5.601	1.932	0.004***	0.375
Behavior ← C4	6.041	2.078	0.004***	0.390
Behavior ← C5	6.173	2.135	0.004***	0.362
Behavior ← C6	7.091	2.392	0.003***	0.588
Behavior ← C7	8.796	2.958	0.003***	0.656
Behavior ← C8	7.115	2.428	0.003***	0.444
Behavior ← C9	8.328	2.799	0.003***	0.671
Behavior ← C10	7.354	2.485	0.003***	0.551
Behavior ← C11	6.035	2.148	0.004***	
0.380				
Behavior ← C12	5.621	1.942	0.004***	
0.378				
Consciousness/Knowledge ← A1	1.000	–	–	
0.880				
Consciousness/Knowledge ← A2	1.020	0.025	0.000***	
0.924				
Consciousness/Knowledge ← A3	0.908	0.027	0.000***	
0.819				

Consciousness/Knowledge ← A4		0.570	0.035	0.000***	0.486
Consciousness/Knowledge ← A5		0.553	0.032	0.000***	0.517
Consciousness/Knowledge ← A6		−0.033	0.017	0.052*	−0.063
Consciousness/Knowledge ← A7		−0.024	0.018	0.196	−0.042
Consciousness/Knowledge ← A8		0.004	0.018	0.829	0.007
Consciousness/Knowledge ← A9		0.014	0.018	0.434	0.026
Consciousness/Knowledge ← A10		0.580	0.034	0.000***	0.478
Perception ← P1	1.000	–	–		0.370
Perception ← P2		0.587	0.117	0.000***	0.183
Perception ← P3	1.509	0.138	0.000***		0.696
Perception ← P4	1.696	0.152	0.000***		0.745
Perception ← P5	1.676	0.150	0.000***		0.761
Perception ← P6		1.671	0.149	0.000***	0.768
Perception ← P7	1.376	0.136	0.000***		0.551
Perception ← P8	1.817	0.162	0.000***		0.761
Perception ← P9		1.359	0.145	0.000***	0.458
Perception ← P10	1.504	0.142	0.000***		0.686
Perception ← P11	1.656	0.154	0.000***		0.758
Perception ← P12	1.380	0.134	0.000***		0.549
Perception ← P13	1.668	0.151	0.000***		0.765

X2	3124.889
DF	347
RMSEA	0.085
CFI (Comparative fit index)	0.921
TFI (Tucker-Lewis Index)	0.866

The structural equation model has been evaluated by the maximum likelihood estimation method using Python. The results of the SEM model are expressed in Table 2. The goodness-of-fit statistic measured by the Chi-square statistic showed that the proposed model is good enough; the Chi-square statistic is 3124.889 with 347 degrees of

freedom (p = 0). The comparative fit index (CFI) amounts to 0.921, which is excellent, and following the Tucker-Lewis index (TFI) is 0.866. In addition, the root mean square error of approximation statistic (RMSEA) is 0.085, below the acceptable upper limit of 0.1 (Fernandez, A., 2013; VanderPlas, J., 2016).

Results

The model results show that NCRE behavior is most influenced by perceptions and attitudes towards NCRE, followed by awareness (knowledge of NCRE). The standardized loading factor for these variables is statistically significant (p-value is less than 0.01), so it can be concluded that perception determines NCRE behavior by 32.8%, with other conditions unchanged. Awareness of NCRE contributes to one's behavior in a slightly lower percentage, estimated at 20.7%. Therefore, the results show that the contribution of students' perceptions and attitudes toward NCRE is higher than that of awareness towards NCRE. The relationship between cognition and perception is also statistically significant (with a statistical significance of 5 %) and stands at 7.6 %, which shows that, depending on one's awareness, perceptions towards NCRE could change.

Although awareness and norms have a positive impact on student behavior, informative and promotional campaigns based on informative messages should be carried out.

In general, the students surveyed believe that, in addition to NCRE, hydroelectric power plants and oil are the most important in our energy system. There is a good perception regarding NCRE for mitigating environmental deterioration despite needing more training and knowledge. On the other hand, students find that hydroelectric power plants and NCRE projects play a vital role in reducing energy independence. Additionally, they are interested in contributing to specific energy-saving actions and using NCRE to the extent of their capabilities. Finally, most respondents agree with the need for training courses for students of environmental careers oriented to education in non-conventional renewable energies.

Conclusions

At the end of the analysis of the results, it can be concluded that, of the three elements of study in this research (awareness/knowledge, perception, and behavior), perception explains more substantially the behavior towards NCRE. Perception determines 32.8% of NCRE

behavior while keeping the other conditions unchanged. Awareness (knowledge) explains 20.7% of NCRE behavior.

It has also been possible to confirm the statistical significance of the impact of awareness (knowledge) on perception using the SEM model. From the point of view of an action that should be taken and is derived from these results is that training courses should be based on disseminating information to students regarding the benefits of NCRE sources to contribute to an adequate perception of them.

Finally, it should be emphasized from the point of view of this research that there is a gap between attitudes and behavior that determines an additional obstacle that prevents a better and greater penetration of NCRE sources in the national energy grid, as well as an acceptance and promotion of NCRE. Therefore, an imperative recommendation is to conduct training courses that positively impact the reduction of the gap, which would ultimately result in a greater willingness of students to think more proactively about NCRE, thus also improving NCRE awareness.

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