'Clean' vs. 'Green': redefining renewable energy (evidence from Bulgaria)

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Renewable Energy Sources. Are they 'Clean' or are they 'Green'? What do those with no previous or biased experience think? This study examines how the term "Renewable Energy" is viewed by primary school students in Bulgaria. For this purpose, a face-to-face survey was applied, aiming at the elicitation of the students' preferences for the naming and the colour that best represents Renewable Energy Sources. This was done with an in-class information project, followed by the completion of a questionnaire. Findings contradict what is, so far, established, i.e. that Renewable Energy Sources are 'Green' and that Renewable Energy is 'Green Energy'.

Keywords: clean energy, education, green energy, public awareness, renewable energy sources

INTRODUCTION

Over the last decade, the terms 'Renewable Energy', 'Clean Energy' and 'Green Energy' are becoming all the more popular in academic research and the public. But are their definitions clear? Are 'Green Energy' and 'Clean Energy' just other terms for Renewable Energy? If this is the case, which term is more suitable to define Renewable Energy? The various different definitions that exist have led to the confusion about the meanings that each term is attributed.

For example, in the USA's Environmental Protection Agency's (EPA) website, Clean Energy is defined as including "renewable energy, energy efficiency and efficient combined heat and power" [1], suggesting that Renewable Energy is a subset of Clean Energy. Green Energy is not defined by EPA; the closest term is 'Green Power', defined as "electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources"; a subset of Renewable Energy [2]. The combining of these two definitions merely suggest that Green Power is a subset of Clean Energy.

As far as the academic community is concerned, is it 'Clean Energy' or 'Green Energy' the term that is used in larger volumes? Extracting information from the Scopus database [3] from 1990 to 2016, we observe that the number of studies containing the term "Clean Energy" in their title are 901, while the ones containing the term "Green Energy" are 625. Interestingly enough, there is not one study containing both terms in the title, and only 16 containing both terms in their keywords.

In addition, there are several academic Journals with reference to Renewable, Clean, or Green Energy. For example, Springer, in its category-search field, it includes the category "Renewable and Green Energy" [4]. Table 1 consists of examples of Journals that make references to Renewable Energy, Green Energy, or Clean Energy in their titles or Aims and Scope.

The *'International Journal of Renewable Energy Research'* [8] merely equates Renewable Energy to Green Energy: *".... the various topics and technologies of renewable (green) energy resources", "Green (Renewable) Energy Sources"*, while it refers to Clean Energy as a different subject: *"Sustainable and Clean Energy Issues"*.

How informed is the public about subjects related to Renewable Energy? On Google, a hit on the terms 'Green Energy' or 'Clean Energy' gives Wikipedia's page on *'Renewable Energy'* [17] as the first result. In addition, the *'Green Energy Institute'* [18] states that "Our policy program and projects promote renewable energy development". These are examples indicating that Green Energy is regarded as having the same meaning as Renewable Energy. Could it be that these three terms are regarded as synonyms by the public?

Table 1. Journals Referencing to Renewable, Green or Clean Energy

Journal	With reference to:		
	Renewable Energy	**Green Energy**	**Clean Energy**
Renewable Energy [5]	✓	✗	✗
International Journal of Green Energy [6]	✗	✓	✗
Journal of Modern Power Systems and Clean Energy [7]	✗	✗	✓
International Journal of Renewable Energy Research [8]	✓	✓	✓
International Journal of Sustainable Energy [9]	✓	✗	✗
International Energy Journal [10]	✓	✗	✗
Journal of Technology Innovations in Renewable Energy	✓	✗	✗
International Journal of Smart Grid and Clean Energy [12]	✗	✗	✓
Journal of Clean Energy Technologies [13]	✗	✗	✓
International Journal of Sustainable and Green Energy [14]	✓	✓	✗
Current Sustainable/Renewable Energy Reports [15]	✓	✗	✗
Renewable and Sustainable Energy Reviews [16]	✓	✗	✗

On the contrary, Google's page on *'Renewable Energy'* [19] makes no reference to the term 'Green Energy'. It only uses the term 'Green Power'; the same as EPA. The page's section in 'Investing in a Clean Energy Future Investments', contains the following sentences: *"We're investing in clean energy"* and *"... agreements to fund nearly $2.5 billion in renewable energy projects"*. Is Google equating Clean Energy to Renewable Energy?

As defining Renewable Energy is a quite complex issue, we aim at examining the term and colour preference of primary school students, as they are less biased by previous formal or informal education. Keramitzoglou et al. [20] conducted face-to-face interviews with students and adults in Greece, in order for them to choose their preference

in the naming and colour that best represent Renewable Energy Sources (RES). We conduct a similar experiment in Plovdiv, Bulgaria, over a sample of 203 primary school students, aged 7-10, with face-to-face interviews and the completion of questionnaires.

We focus on introducing a method that could be applied to other regions and countries, so as to extract information on how the untrained eye views the subject, aiming at redefining Renewable Energy. What is important is the integration of the analysis of behavioural patterns in environmental issues, so as to examine the ways with which resources could be better managed. The rest of the paper is structured as follows: Section 2 consists of the detailed method of the data collection, Section 3 consists of the results and discussion of our analysis, and Section 4 of the overall conclusions and further research suggestions.

DATA AND METHOD

In this section, the education system in Bulgaria is presented, followed by the description of the school where the survey took place, and the discussion of the questionnaire used to conduct our research. We describe how we reach an answer to the hypothesis that the choice of the colour Green for best representing RES results from the way energy is represented in nature textbooks, in addition to education in and out of school.

Curriculum

School education in Bulgaria is mandatory for all children aged between 7 and 16. Grades 1 to 4 form the primary school education, with pupils of ages from 7 to 10. One of the main subjects taught in Bulgarian Primary Schools is 'Natural sciences and ecology', with energy related subjects appearing for the first time at the end of the first semester in the 3rd grade in the course called "Man and Nature" [21]. The students are taught the basics in water and air purity, as well as introductory references to sources of electricity. In the 4th grade, the subject "Bodies and substances" covers several topics, such as types of energy, energy sources and clean water protection [22].

Sample

The students participating in the face-to-face interviews and the completion of the questionnaire are all from 1st to 4th grade; 7 to 10 years old. The survey was conducted at the Secondary School Bratia Miladinovi in Plovdiv, Bulgaria, established in 1935 and covering the school districts "Ear" and

"Brickworks" in the Ist urban area Kuchuk-Paris. The school area consists of two well-preserved and maintained school buildings, with two computer laboratories with internet access, and a well-established library. Sufficient infrastructure is available, so as to allow one-shift learning mode. "Brothers Miladinovi" is the only school in Plovdiv that implements the project "Inclusive Education" BG051PO00-4.1.07, funded by the European Social Fund of The European Union, with its overall objective being to provide a supportive environment for opening up education and providing equal access, aiming at detecting learning difficulties, promoting successful socialization and integration, and quality education tailored to the individual students' needs.

Questionnaire

The school teacher conducting the survey was given a 4-Step instruction quide on how to brief the students before the interviews. The teacher had strict instructions as not to make any reference to pollution or clean energy throughout the process. The steps are as follows:

1. Explaining of the definition/ notion of Energy. For example, humans, in order to move, they need energy, which is covered by daily intakes of food.

2. What do electrical equipment, such as lamps, need in order to function? Electricity. How is it produced in Bulgaria?

3. If we constantly consume our sources from which electricity is produced, are they ever going to end? Explaining of "Renewable Energy Sources" and "Non-Renewable Energy Sources".

4. Provide examples of RES. Sun, wind, waterfalls, waves, biomass, etc. Utilization technologies of RES. Solar panels, windmills, watermills etc.

The questionnaire, apart from demographics such as age, grade etc, consisted of two main questions: 1) Which of the following definitions best describes, to your opinion, «Renewable Energy Sources»?, with the options being 'Clean Energy' or 'Green Energy', and 2) Select the colour that, to your opinion, best describes «Renewable Energy Sources», with the options being a green box, a yellow one, and a white one. We prepared six variations of the questionnaire, with the order or the answers being changed, so as to avoid order bias. They were given out in the order shown in Table 2.

The teacher interviewed each student one by one, in a quite space, where the students could not communicate with one another while responding to the questions. The interview was the first time that the terms Clean Energy and Green Energy were mentioned to the students. The above mentioned research protocol was the same as the one used by Keramitsoglou et al. [20].

**Table 2.** Variations in the order of options in the questions

Variation	1st Question	2nd Question
I	Green - Clean	Green White Yellow
II	Clean - Green	White Yellow Green
III	Green - Clean	Yellow Green White
IV	Clean - Green	Green White Yellow
V	Green - Clean	White Yellow Green
VI	Clean - Green	Yellow Green White

RESULTS AND DISCUSSION

During the experiment, a total of 203 students participated; 46 students are in 1st grade (about 7 years old), 59 in the 2nd grade (about 8 years old), 50 in the 3rd grade (about 9 years old), and 48 in the 4th grade (about 10 years old). Out of 203, 111 were girls and 92 were boys. This experiment took place during February 2016. In all four grades, the preferred term for representing Renewable Energy is 'Clean Energy'. Fig.1 shows the percentages in the selection of 'Clean Energy' and 'Green' Energy, and the colour for the better representation of Renewable Energy per grade level.

In the 1st, 2nd and 3rd grade, 'Clean' got scores of 76%, 80% and 70%, respectively. In the 4th grade, though 'Clean' was again the students' choice, it got a score of 56%; significantly lower than the other grades ($X^2 = 6.5764$, $p < 0.05$, if 1st to 3rd grade are compared as a group with the 4th grade). These figures complement the findings of Keramitsoglou et al. [20], showing that, for students of the same age in Greece, about 78% of the 1st and 2nd grade chose the term 'Clean' for best describing RES.

Table 3 consists of the Chi2 figures for the comparisons among grades for selecting Green as the term of choice (compared to 'clean') for naming RES. Statistical differences are not observed among students attending the 1st, 2nd and 3rd grade. On the other hand, students attending the 4th grade report statistically significant higher rates for 'Green' compared to 'Clean' as their preferred term for naming RES, compared to those attending the 1st and 2nd grade ($X^2 = 4.117$, $p < 0.05$ and $X^2 = 6.801$, $p < 0.01$, respectively). Students attending the 3rd grade provided responses close to the first two grades, but this was not statistically different compared to the responses of the 4th grade.
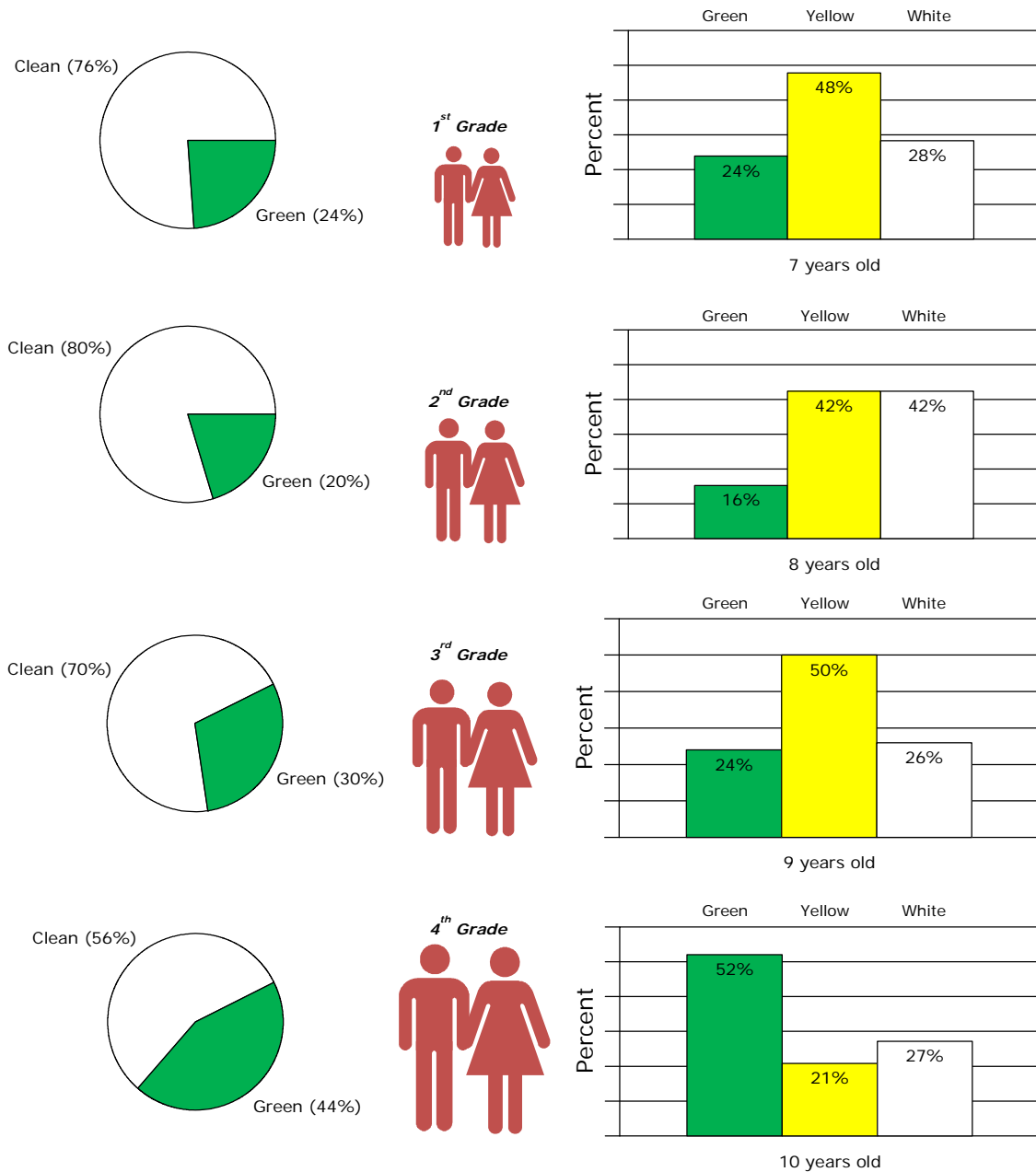
Fig.1. Percentages in the naming and colour selection for representing Renewable Energy per grade level

Table 3. Chi2 figures for selecting 'Green' for naming RES

Grade	G1	G2	G3	G4
G1	0			
G2	0.1930	0		
G3	0.4495	1.3556	0	
G4	4.1166*	6.801**	1.9923	0

*$p<0.05$, **$p<0.01$

As far as the preference in colour is concerned, in the 1st and 3rd grades 'Yellow' is the colour achieving the highest scores, with 48% and 50% respectively, with 'White' being the second choice. Yellow was also the most preferred colour in representing RES in the 1st and 2nd grade students in Greece [20]. In the 2nd grade, yellow and white each received 42%. In all three grades, 'Green' achieved the lowest scores. In the 4th grade, though, 'Green' got the highest percentage (52%), supporting our hypothesis that the choice of 'Green' for the colour best representing RES results from the way energy is represented in nature textbooks, in addition to

education in and out of school. Table 4 consists of the Chi2 figures for the comparisons among grades for selecting Green (instead of yellow or white) as the colour of choice for labelling RES.

Statistical differences are not observed among students attending the 1st, 2nd and 3rd grade about their preference in the green colour as their choice in representing RES. On the other hand, the preference of the students attending the 4th grade for 'Green' was significantly higher than those of the students attending the 1st, 2nd and 3rd grade (X^2=7.888, $p<0.05$, X^2=16.560, $p<0.001$, and X^2=8.219, $p<0.01$, respectively).

Table 4. Chi2 figures for selecting 'Green' as the colour of choice for labelling RES

Grade	G1	G2	G3	G4
G1	0			
G2	1.2568	0		
G3	0.0001	1.3309	0	
G4	7.8882*	16.5599***	8.2187**	0

*$p<0.05$, **$p<0.01$, ***$p<0.001$

Based on the above, we suggest that very young students with little or no exposure to the concept of Renewable Energy in Bulgaria are most likely to choose 'Clean' as the term for labelling RES and (not Green but) Yellow as the colour for best representing it. As students receive formal (followed by informal) education, their preferences start to shift, and they choose Green Energy and Green as the term for labelling and the colour for representing RES, respectively. These findings support those of Keramitzoglou et al. [20], who reached the same conclusions for students attending primary schools in Greece. While the implementation of energy education projects increase awareness in energy issues [23-24], it is important to elicit the students' preferences and adjust the findings in behavioural patterns, so as to contribute to the efficient use of RES and, consequently, natural resources.

CONCLUSIONS

This study examined the preferences in naming and colour for the best representation of RES of primary school students, by conducting face-to-face interviews to 203 primary school students aged 7-10, in Plovdiv, Bulgaria. We aimed at introducing the methodology to be also applied in other regions and countries, so as to contribute to the discussion of defining Renewable Energy as 'Clean' instead of 'Green'.

The results show that, for describing Renewable Energy, the preferred term is 'Clean' for all grades, but with significantly lower percentage in the 4th grade. In selecting the colour that best describes Renewable Energy, in the first three grades the first choice was yellow, followed by white, but in the 4th grade the students selected Green with significantly higher percentages than the other three grades.

Overall, though 'Green' seems to be the term and colour that most select as the one describing RES, we see evidence that, for children not yet exposed to formal or informal education on the subject, the term 'Clean Energy' is the first choice for describing Renewable Energy, while for the colour, yellow and white are clearly the choice for representing RES. Similar research on the subject should be applied to other regions, so as to further explore the name and colour that is the most suitable to represent Renewable Energy.

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