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ORIGINAL RESEARCH

An Approach on the Renewable Energy Sources

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Abstract

The energy upgrade of buildings and the green transition is one of the largest projects currently being implemented in Greece. At the same time, the development of island interconnections is essentially the passage for the transition of renewable energy to the Greek mainland or vice versa, the creation of storage units, the treatment of poverty in energy, the undergrounding of networks, etc. The strategy of the present research concerns the design of a questionnaire according to the latest developments in the field of energy upgrading in Greece for both the mainland and the island part of the Region of Thessaly. At the same time, the questionnaires emphasize renewable forms of energy as they are characterized by Directive 2009/28/EC (wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydroelectric, biomass, photovoltaic, etc.). Based on the present research and its results, it is proposed to conduct a broader research by all scientific bodies involved in energy management, so that the new emerged data could be a start for a comparative study in all the Regional Departments of the Country.

Keywords Energy · Aerothermal · Biomass · Geothermal · Hydroelectric · Hydrothermal · Ocean · Photovoltaic

1 Introduction

The purpose of this work is to compile proposals arising from research through a questionnaire, in which undergraduate students of the Civil Engineering Department of Technological Education (T.E.) in Larissa took part, along with

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postgraduate students of the Postgraduate Program "Advanced Environmental Management Technologies in Engineering Works" organized by the General Department of the University of Thessaly, Professors of the University of Thessaly, Academic Scholars, and Institutions that deal with the management and utilization of energy, with the ultimate goal of highlighting the optimal choice of energy supply in both homes and public buildings, as well as large infrastructure projects. A questionnaire on the existing renewable energy sources (RES) defined by Directive 2009/28/EC took place during this research, both in mainland and island part of the Region of Thessaly.

In fact, renewable energy sources are flexible applications that can produce energy commensurate with the needs of the local population, eliminating the need for huge power plants (primarily for the countryside) but also for energy transport over long distances.

For compiling the questionnaires, the possibilities of the supplied energy items, their efficiency, the means of production as well as the way of their transportation were considered variables [1–3]. The questionnaires used various types of questions such as open-ended completion and development questions as well as closed multiple-choice, hierarchical, and ranking questions [4–6]. The responses were evaluated, and useful conclusions were drawn which could contribute positively to a better utilization of the provided forms of energy as well as to an improvement of the efficiency during the end use with a main aim to reduce the environmental imprint. The majority of respondents are more positive about solar thermal, photovoltaic systems, and wind energy.

The above different types of energy, described in detail in a next unit, are wind, solar, aerothermal, geothermal, hydrothermal and ocean, hydroelectric, biomass, and photovoltaic.

Conclusions of this research are drawn at the end, aiming to reduce the environmental imprint.

2 Literature Review

In this study, renewable energy sources (RES) were defined, presented, and discussed. Articles [1–6] were particularly useful because they reinforced the theoretical background of the work both at the level of questionnaire organization and at the level of research teaching. O'Sullivan and Barnes research work [7] which investigates Energy Policies helped compile the questionnaires considered in the survey of 115 respondents. The articles by Edenhofer et al. [8] and Hu et al. [9] led to the definition of aerothermal energy, the work by Smith et al. [10] led to the description of biomass, while the National Geographic Environment [11] occupied with the geothermal energy. The publications of Ansar et al. [12], Macknick et al. [13], and Le and Pitts [14] refer to hydroelectricity which is the largest producer of renewable energy sources (RES). According to Jagusztyn [15], hydrothermal energy is the process of obtaining heat or energy from a large body of water while according to

the US Government Accountability Office (GAO) [16] and the National Renewable Energy Laboratory of the US Energy Department [17], the most common methods of ocean energy are three: the production of energy from the waves, the tides, and the temperature differences of the water. The Fraunhofer Institute for Solar Energy Systems [18] and the Utah State University Institute of Political Economy [19] report on how to harness solar energy. Finally, the United Nations Statistics Division, Energy Statistics Section [20] presented the annual questionnaire on energy statistics which helped a lot not only in the theoretical background of the work but also in the evaluation of the answers. It should be emphasized that this paper is original and differs from previous works both in the form of the questions and the resulting conclusions which are particularly interesting.

3 Methodology

In this study, a survey through a questionnaire was conducted. The main goal for the reliability of the results was to ensure many participants such as students, professors, and fellows of the University of Thessaly, considering the total number of academia's students and staff.

The selected method for this work was the use of open-ended and closed-ended type of questionnaire, as they tend to allow researchers to collect reliable data that can be interpreted easily, quickly, and economically. In addition, the answers are not influenced by the researchers, while the collected information can be easily converted into quantitative data in order to perform statistical analysis.

Closed-ended type questionnaires have preset standardization, and all the participants answer the same questions in the same sequence. These questions allow the respondent to choose only one of the predetermined answers. Closed-ended questionnaire types are noticeably clear, and their processing is much easier than other questionnaire types. Consequently, a survey based on closed-type questionnaires can be easily replicated or repeated, to verify the reliability of results. An open-ended questionnaire allows researchers to collect qualitative data, as open questions allow for elaboration on the answers provided by the respondents. In these questions, respondents can express their own opinion freely, without restrictions. The procedure is useful in cases where the researcher is uncertain about the type of answers and obviously allows him/her to have some insight into the motive behind a certain attitude of the respondent [7].

A questionnaire is a powerful and very important assessment tool. Its form includes a series of structured questions, which the respondent is asked to answer in writing, following a specific order. The structure of the questionnaire, due to its properties, is the most critical and delicate work, crucial for the success of a statistical survey. Questionnaires collect data asking people to answer the exactly same set of questions. Data analysis includes the management of the qualitative and quantitative data collected from the rounds of the questions, as well as the examination of the change of attitude by the experts that occurs between the rounds of the questions. This is a structured process, which is usually illustrated in a graph as a result of collecting the answers.

4 Energy Definitions-Descriptions

For the purpose of a global information on the existing forms of energy, a brief description is following, mainly presenting the source, the procedure of production, the main producers in the world, the availability, the percentage with respect to other forms of energy, etc. So:

- *Aerothermal* energy [8, 9] refers to a technology that is responsible for harnessing the energy found in the air in the form of heat, in order to use it at home, by heating or cooling or making hot water. It is responsible for extracting up to 77% of the energy from the air for free. It would be like an advanced heat pump that is designed specifically to provide cooling in summer, heating in winter, and hot water throughout the year.

  The *air conditioner* is based on two main components: evaporator, located inside the house and the outdoor unit which includes compressor and condenser.

  Both elements are linked by a circuit with refrigerant and the key to its operation is in the changes of temperature and the state of the refrigerant.

  Through the changes of state of the *heat-cold* or *gas–liquid* refrigerant, the air conditioner transfers fresh air to the room and hot air to the outside in summer.

  The cycle is reversed in winter.

  In addition, the aerothermal system generates hot water for the radiant floor.
- *Biomass* [10] is a plant or animal material used as fuel to produce *electricity* or *heat*. Examples are wood, *energy crops*, and waste from forests, yards, or farms. The word biomass denotes the biological raw material that the fuel is made of. The word biofuel is usually reserved for *liquid* or *gaseous* fuels, used for transportation.

  The *IPCC* (Intergovernmental Panel on Climate Change) defines *bioenergy* as a renewable form of energy. In 2017 the *IEA* (International Energy Agency) described bioenergy as the most important source of renewable energy. Researchers have disputed that the use of forest biomass for energy is *carbon neutral*.

  Wood and wood residues are the largest biomass energy source today. Wood can be used as a fuel directly or processed into *pellet fuel* or other forms of fuels. Other plants can also be used as fuel, for instance *corn*, *switchgrass*, *miscanthus*, and *bamboo*. The main *waste energy* feedstocks are wood waste, *agricultural waste*, *municipal solid waste*, *manufacturing waste*, and *landfill gas. Sewage sludge* is another source of biomass. There is ongoing research involving algae or algae-derived biomass. Other biomass feedstocks are *enzymes* or *bacteria* from various sources, grown in *cell cultures* or *hydroponics*.

  Biomass is also used to produce fibers and industrial *chemicals*.

  Based on the source of biomass, *biofuels* are classified broadly into three major categories:

  First-generation biofuels are *derived from food* sources, such as *sugarcane* and *corn starch*. Sugars present in this biomass are fermented to produce

bioethanol, an alcohol fuel which serve as an additive to gasoline, or in a *fuel cell* to produce electricity.

Second-generation biofuels utilize *non-food*-based biomass sources such as *perennial* energy crops (low input crops) and agricultural/municipal waste. Proponents argue that there is huge potential for second generation biofuels.

Third-generation biofuels refer to those derived from *microalgae*.

Upgrading raw biomass, higher grade fuels can be achieved by *thermal*, *chemical*, or *biochemical* methods. In conclusion:

The energy that is bound to plant substances comes from the sun. Through the process of photosynthesis, plants transform solar energy into biomass. Animal organisms absorb this energy through their food and store some of it. This energy is finally released by biomass, after processing and use. It is a renewable energy source because it is actually stored solar energy that was captured by plants during photosynthesis.

- *Geothermal energy* [11] is hidden in the earth, although it often makes its presence felt with hot springs and steam. It was first used in Italy in 1904 and a bit later In Iceland in 1907. Today, it is used in over 20 countries, with the USA being the largest producer of geothermal energy in the world. For instance, "The Geysers" *field in California* is spread over *117 km*^{2} and is formed of *22 power plants*.

  Iceland, describing itself as a "*pioneer*" of geothermal power, produces 25% of its energy from *5 geothermal power plants*. This is due to the *600 hot springs* and *200 volcanoes* in the country. In Greece, unfortunately, less than 5% of the country's certified geothermal potential has been utilized to date. The bad start was made in 1989 by the Public Power Corporation of Greece in Milos, where an explosion took place in the unit, playing obviously a negative role, the result of which was the closing of factory.

  However, it is sure that *the time has come to open a substantial debate on exploiting our rich domestic geothermal energy*.
- *Hydroelectricity* or *hydroelectric power* [12–14] is electricity produced from hydropower. In 2015, hydropower generated 16.6% of the world's total electricity and 70% of all renewable electricity and was expected to increase by about 3.1% each year for the next 25 years.

  Hydropower is produced in 150 countries, with the Asia–Pacific region generating 33% of global hydropower in 2013. China is the largest hydroelectricity producer, with 920 TWh of production in 2013, representing 16.9% of domestic electricity use.

  The cost of hydroelectricity is relatively low, making it a competitive source of renewable electricity. The hydro station consumes no water, unlike coal or gas plants.

  The typical cost of electricity from a hydro station larger than 10 megawatts is 3 to 5 US cents per kilowatt hour. With a dam and reservoir, it is also a flexible source of electricity, since the amount produced by the station can be varied up or down very rapidly (as little as a few seconds) to adapt to changing energy demands.

The construction of a hydroelectric complex can cause significant environmental impact, principally in loss of arable land and population displacement.

They also disrupt the natural ecology of the river involved, affecting habitats and ecosystems. While dams can ameliorate the risks of flooding, they also might contain a risk of dam failure, which can be catastrophic.

In hydroelectric power plants (HPPs), the kinetic or dynamic energy of running water is converted into mechanical energy, through a turbine that acts in this case as an energy converter.

Today, the largest HPP in the world is located on the Itaipu River, on the Brazilian-Paraguayan border.

The largest hydroelectric dam in the world was recently built at Three Gorges on the Yangtze River in China.

The first generators were put into operation in 2003 and the project, which includes 26 generators with a total capacity of 18.3 GW, was completed in 2009. The cost of the project exceeded US $100 billion, thus occupying the position of the most expensive technical project in the world. This price did not include the costs of expropriations, population movement, and environmental impact.

In Greece, the Kastraki HPP is used to regulate the flow of power between Greece and Yugoslavia. The HPPs in our country are developed mainly along the rivers Acheloos, Aliakmonas, and Nestos. The largest HPP, in terms of installed capacity, is located in Acheloos, and is the Kremasti HPP, with an installed capacity of 437.2 MW.

- *Hydrothermal* energy [15] is the process of obtaining heat or energy from a large body of water. "Heat," in this case, should not be associated with high temperature (as it may be with geothermal energy) but with a relative temperature difference. The abundance of this renewable energy source was testified by the eminent ocean energy scientist, Hans Krock. "The energy flowing through the surface layer of the tropical ocean is about 10,000 times greater than the energy used by human societies." As such, it is the only energy resource on Earth that is large enough to replace fossil fuel.

  Ocean thermal energy conversion (OTEC) is a subset of what is conceived as hydrothermal energy. Whereas OTEC (also known as hydrothermal power generation) focuses on electrical power generation from ocean temperature difference, hydrothermal energy offers a more comprehensive utilization of the natural water resources.
- *Ocean* energy [16, 17] is a renewable form of energy produced in the seas and oceans. There are several ways to generate energy from the sea. The most common methods of ocean energy are three: the production of energy from the *waves*, the *tides*, and the *temperature differences* of the water.

  The *waves* create kinetic energy which in turn rotates a turbine that produces electricity.

Also, in the case of the *tide*, dams are created, which store the water on the shore during the flood and then it is released and moves a turbine as in the hydroelectric plants.

Finally, the third method utilizes the *difference in water temperature between the water surface and the bottom*. This is based on *Carnot's 2nd law of thermodynamics* where mechanical energy is extracted from the heat flow between a warmer and a colder region.

The factors that are evaluated in order to decide the appropriate locations for the production of ocean energy are the height, length, and speed of the waves. Most often, they are identified with the areas where the wind is stronger. This is because the waves are the result of the intensity of the wind. Wave power generation systems can be installed anywhere in the sea. They can also be anchored at the bottom or floating offshore. In many cases, they are located on the coast or in shallow water.

As a renewable form of energy, its environmental friendliness makes it preferable to those that emit pollutants. At the same time, the huge amount of energy enclosed in the waves makes it very competitive with other renewable energy sources. A very important element of ocean energy is that its production units do not pose risks that could be caused by similar units on land.

This energy also has some disadvantages, which partly justify the fact that it is not so widespread. The main element that concerns is the high cost of construction and maintenance of power plants, a typical model of which is depicted in Fig. 1.

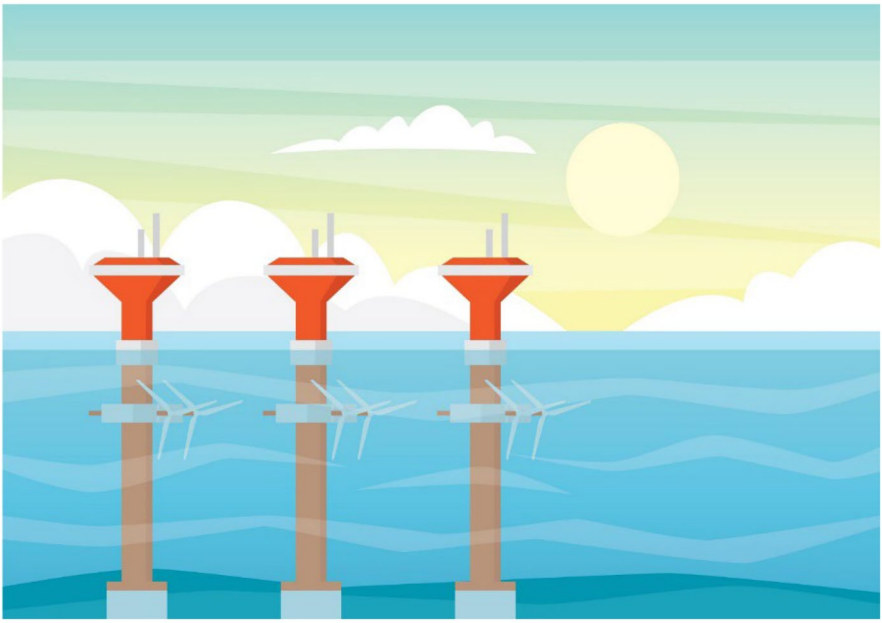


Fig. 1 Typical model of ocean energy power plant [21]

The force exerted on the units by the waves, combined with the corrosion caused by water and sea salt, makes maintenance costly. In addition, many have expressed concern that these units create noise pollution and esthetically alter an area. The above two concerns become more intense when it comes to tourist areas. Ocean energy, as the years go by, is slowly beginning to overcome its disadvantages. This is due to the evolution of technology. With the new technological possibilities, the cost of construction and maintenance is significantly reduced. Thus, the opportunity is given for the further development of the industry. Our country, which is bathed by the sea and has a long coastline, can take advantage of this opportunity.

- *Photovoltaic* solar energy [18, 19] is obtained by converting sunlight into electricity using a technology based on the photoelectric effect, which is a phenomenon studied in physics, photochemistry, and electrochemistry and is utilized for electricity generation and photosensors in commerce. It is a type of renewable, inexhaustible and non-polluting energy that can be produced in installations ranging from small generators for self-consumption to large photovoltaic plants.

A photovoltaic (PV) system consists of solar modules, each comprising a number of solar cells, which generate electrical power. PV installations may be ground-mounted, rooftop-mounted, wall-mounted, or floating. The mount may be fixed or use a solar tracker to follow the sun across the sky.

Hopefully, the photovoltaic technology might produce enough affordable sustainable energy to help mitigate global warming caused by carbon dioxide, CO_2.

Solar PV has specific advantages as an energy source. Once installed, its operation generates no pollution and no greenhouse gas emissions.

The use of PV as a main source requires energy storage systems or global distribution by high-voltage direct current power lines causing additional costs. Production and installation do cause pollution and greenhouse gas emissions and there are no viable systems for recycling the panels once they are at the end of their lifespan after 10 to 30 years.

Photovoltaic systems have long been used in specialized applications as standalone installations. Grid-connected PV systems have been in use since the 1990s. Photovoltaic modules were first mass-produced in 2000, when German environmentalists received government funding for a ten thousand roof program.

Decreasing costs has allowed PV to grow as an energy source. This has been partially driven by massive Chinese government investment in developing solar production capacity since 2000.

In 2019, worldwide installed PV capacity increased to more than 635 gigawatts (GW) covering approximately 2% of global electricity demand.

After hydro and wind powers, PV is the *third* renewable energy source in terms of global capacity.

By April 2015, the total installed photovoltaic power in Greece had reached 2442.6 MW, of which 350.5 MW were installed on roofs, while the rest was terrestrial. Greece ranks 5th in the world in terms of installed photovoltaic power, while photovoltaic power covered 7% of electricity demand in the country in 2019.

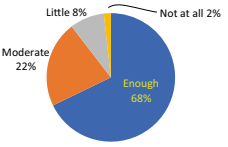
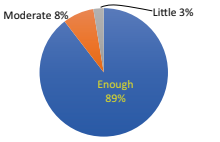
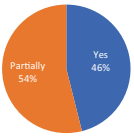
5 The Questionnaire

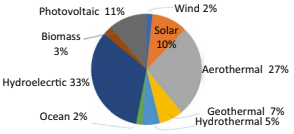
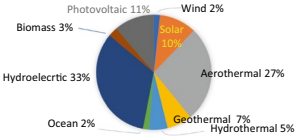
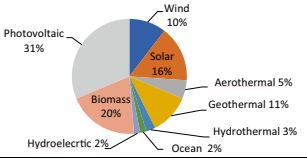
In this survey, a total of 115 respondents took part, who were by definition relevant to the subject matter of the questions.

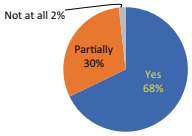
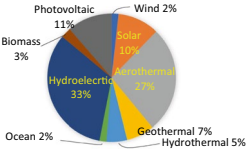
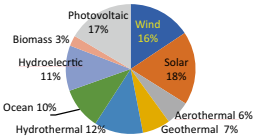
This number was distributed as follows:

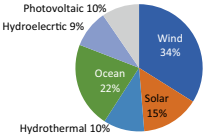
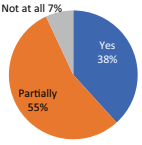
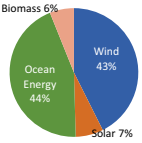
- 67 students
- 23 postgraduate students
- 12 teachers
- 4 academic fellows and
- 9 Institutions

Following are 12 questions which were posed to all 115 respondents. In each of these questions the percentages of the given answers are displayed below in the form of a pie [20]. Each question and pie is accompanied by a brief comment which is related to the given corresponding answers.

Nr	Question	Pie	Comments
1	How informed are you about the different types of renewable energy sources (RES) used by current technology?		Seeing the percentages, we notice that the vast majority of respondents are already aware, probably from the fact that their scientific information covers the different types of current technology.
2	To what extent do you consider RES to be environmentally friendly?		Here, too, the vast majority consider that the Renewable Energy Sources are environmentally friendly.
3	Are you aware of the different types of energy known today? i.e.: a) Wind b) solar c) Aerothermal d) Geothermal e) Hydrothermal f) Ocean energy g) Hydroelectric h) Biomass and i) Photovoltaic?		Here it seems that everyone is fully or partially aware.

Nr	Question	Pie	Comments
4	Of course, depending on the type, each energy is related to its production cost. Given your place of residence or activity, do you know how energy is related to its consumption costs?		Here, too, the vast majority know the energy to cost-benefit ratio, but not for all species.
5	Finally, which of the following energies would you prefer for home use?		It appears here that the majority of respondents prefer the classical forms of energy while at the same time maintain a cautious attitude towards the other, innovative forms.
6	Respectively, which of the following energies would you prefer for industrial or other use?		On the contrary, in industrial use there is a reversal of the respondents that comes mainly from photovoltaic and biomass.

Nr	Question	Pie	Comments
7	Do you think that by using a RES, there would be some financial benefit in the long run?		Here all respondents express their confidence in the Renewable Energy Sources
8	Do you use any form of RES and if so what is it?		Here the clear majority tend to adopt the classical forms of energy, as their production and marketing is widespread
9	Which of the following types of energy do you think could play an important role to face the energy problem? (Select up to three items		Here we would say that the majority of respondents rely mainly on the sun and wind energy

Nr	Question	Pie	Comments
10	Which of the following types of energy do you consider most environmentally friendly?		Here the belief, that the wind and the sun energy are more environmentally friendly, is repeated, but without ignoring the ocean energy, which, according to the experts, is constantly gaining ground
11	Do you think that a complex combination of two or more types of energy could be more appropriate?		The majority of respondents, perhaps for security reasons, believe that a combination of energy sources would be preferable
12	If you were appointed to implement a European energy policy, what kind of RES would you suggest, so that an energy crisis on the planet would be avoided?		According to the answers, the ocean, wind and solar energy would play an important role to prevent a planet crisis, because they are available in all European countries and also are environmentally friendly

6 Conclusions

1. The majority of respondents, knowing the energy to cost ratio, prefer the traditional forms of energy for home use, but consider that other innovative energy sources are also very environmentally friendly, and it is a matter of time before they replace other types of energy.
2. Renewable energy sources are considered by almost everyone to be completely environmentally friendly and according to most, some of them can solve the energy problem of the planet.
3. However, based on the present research and its results, *it is proposed to conduct a broader research by all scientific bodies involved in energy management*, so that the new emerged data could be a start for a comparative study in all the Regional Departments of the Country.

Data Availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest The authors declare no competing interests.

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