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Preparing the Public Opinion in the Community to Accept Distributed Energy Systems and Renewable Energy

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Abstract: Global energy consumption has reached unprecedented levels over the last century due to population growth and economic growth. There have been significant changes in the global energy economy to reduce greenhouse gas emissions and air pollutants. Due to this trend, many countries around the world are promoting electric technologies as fuel-saving alternatives. The Israeli energy industry integrates renewable sources into its supply system and streamlines consumption. Nevertheless, Israelis know too little about smart meters, energy storage systems, and other modern power grid technology, which enables a decentralized approach to energy management referred to as distributed energy systems (DES). Using distributed energy systems to generate energy on-site and manage loads can reduce costs, improve reliability, and secure revenue. An effective public education program can help prepare public opinion and reduce barriers to smart use and energy efficiency in the home. By educating schoolchildren, we will present a way to prepare the public in the community to accept distributed energy systems and renewable energy. In challenging times, it is vital to make great efforts and to remember that change begins with education and that the best way to achieve intelligent usage and energy efficiency is to start with our children.

Keywords: environmental education; elementary school; renewable energy; distributed energy systems; sustainability

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1. Introduction

Installing a distributed energy system (DES) can help reduce the energy distribution losses and allow usage of locally available renewable resources. DES can combine different sectors, such as electricity, cooling, and heating, using technologies such as cogeneration, heat pumps, absorption chillers, etc. The rising concerns about energy independence, global warming, and climate change, coupled with the demand to provide electricity to remote populations, has encouraged a change in thinking toward energy systems. Consequently, the focus is directed towards developing power plants located close to end-users and designing plans in accordance with local needs and resources [1]. The DES concept involves both the deployment of generation plants (decentralized generation) and the integrating of various energy sources [2]. The distributed production of DES has many benefits: economic (e.g., local resource development), technical (e.g., system flexibility), and social (e.g., self-sufficient communities). With the rise of interest in DES, a variety of aggregation solutions are being developed in the scientific community. The following concepts are the prominent ones. However, it is important to note that the terminology is still developing and uncertain, and in some cases, it is used indistinctly.

Microgrids can be addressed for both centralized and decentralized generations. Other approaches are poly-generation, which involves the generation of more than one energy vector from a single process, or hybrid energy systems, in which there is more than one energy conversion device or source involved in the process of energy generation. Because of its various advantages, both developed and developing countries increase their interest in DES, and they use many different strategies to facilitate the application of its design. In this section, we will review the strategies used in the US, Europe (Germany, Italy, and Britain), China, and Israel.

1.1. The United States

In the past decade, the U.S took various actions to encourage the development of Combined Heating & Power (CHP) and renewable energy utilization. According to the White Paper on CHP in a Clean Energy Standard from 2011, the CHP share of the U.S electric power is expected to increase by 11% and represent 20% of the electricity generated by 2030 [3]. Furthermore, the Department of Energy and the Environmental Protection Agency have decided to replace the old equipment in the industrial sector with more clean and efficacious distributed energy equipment [4]. In the past two decades, the US established several initiatives to reduce the prices of natural gas and to improve the development of clean energy, and several related policies have been issued. For example, in 2011, the Blueprint for a Secure Energy Future was issued [5]. The plan aims to reduce the dependence on oil by exploiting cleaner alternative energy. Subsequently, the Clean Power Plan was published in 2015 to promote renewable energy power [6].

1.2. Europe

Overall, renewable energy represented 22.1% of the energy consumed in the European Union (EU) in 2020 [7]. In this section, we review the steps taken by some of the governments in the last decade which have enabled the EU to reach the percentage stated above, as well as goals for the next decades and further measures that are planned to be taken.

1.2.1. Germany

Germany has been determined to decrease greenhouse gas emissions and has taken several measures in that direction. In 2012, the government set a legally binding development target that by 2025, the electricity generated by CHP will account for 25% of the total generation [8]. This commitment is bound by a law named Combined Heat and Power, which also states that the electricity from CHP will receive a higher subsidy and will become a higher priority. In addition, a series of policies have been released, such as the Law on Renewable Energies from 2012, which specifies that biomass-based power plants should assist the development of the CHP deployment and its related policies mentioned above. In 2015, Germany declared that nuclear power would gradually be removed by 2022, facilitating the deployment of CHP. These policies place Germany as the country with the largest segment of the CHP market among EU members. Furthermore, the government revised the Law on Renewable Energies again in 2016, and suggested new goals: by 2030, the electricity generated by renewable energy will account for 50% of the total generation, and this will be over 80% by 2050.

1.2.2. Italy

In 2020, the proportion of renewable energy of the total primary energy consumption in Italy accounts for 20.4%, higher than the goal of 17% that had been set in 2009. Italy has carried out major supporting strategies to achieve the target. Italy has improved its traditional medium-voltage public grid while putting an emphasis on the research of terminal equipment in the smart grid. In 2017, the National Energy Strategy was revised, with a new goal of renewable energy reaching 28% of the total energy production by 2030 [9–11].

1.3. The United Kingdom

The British government has embraced several cost-sharing strategies aimed at decreasing the high cost of PV, such as allocating the cost of photovoltaic generation to fossil fuel-based energy producers through taxes and financial subsidies. Furthermore, the British government has urged energy producers to cut carbon emissions and to save energy. For instance, an enterprise that improves its primary energy saving ratio to a particular value would be eligible for government credit as well as VAT on the installation cost of the equipment. By 2013, the installed capacity of CHP in Britain was about 420,104 kW, accounting for 10% of the total electrical output [12]. While in 2016, 45% of the total electricity was generated by natural gas power plants, and the thermal power plant was slated to be phased out by 2025 [13].

1.4. China

China has had the world's largest PV market share since 2013. As the price of the PV module falls, the government keeps increasing the amount of PV capacity installed, along with providing incentive policies such as feed-in tariffs (FITs) and subsidies. Until 2016, large-scale PV power stations were the most dominant in the PV market in China [14].

Since 2016, distributed PV energy developed very quickly, and it is now one of the foundations of China's energy transition. However, considering the Chinese market, distributed energy still has a major potential to develop. China has been promoting policies favoring distributed energy in the past decade, and the government keeps adding new policies to support it and create a promising environment for distributed energy to continue to develop and grow.

2. Education

It is necessary to design, develop, and disseminate appropriate renewable energy technologies so that economic growth and human welfare are enhanced [15,16]. Along with governmental support, establishing and applying policies for distributed energy to form a significant percentage of all electricity generated, there is a need for change in education as well. The emerging needs of the 21st century for sustainable energy supply systems have been accompanied by fresh approaches to renewable energy education, which aims to address the needs of the current times. As the renewable energy industry is developing rapidly, concerns about oil reduction and climate change are rising. Many perceive renewable energy as part of the answer to these concerns, including the governments mentioned above, and others that have formed programs to promote the use of sustainable energy systems. However, many engineers and professionals are not qualified to work with these renewable energy technologies, and most are not familiar with the principles of sustainability. Hence, there is a crucial need to develop and implement new training programs and courses that will prepare engineers, energy planners, and scientists for the market of the 21st century, which is expected to be dominated by sustainable energy solutions.

Renewable energy education is a relatively new field, and it normally includes special techniques, standards, and requirements that are not typically included in other disciplines. These programs include, or should include, all the stages of renewable energy, from the study of the technology and resources to systems design, economics, industry structure, and policies that support it.

Education is a powerful agent of social and perceptual change. It can serve as a tool to raise awareness of the latest trends and developments and provide suitable training for professionals. In addition, it can support government efforts, as it can familiarize the public with innovative technologies and create confidence in new products [17]. The community has a key role in the success or failure of the implementation of recent technologies. Jennings listed some of the purposes that education can fulfill in the success of implementing renewable energy systems [17]:

- Raising public awareness of the technology.
- Instilling confidence in the technology among consumers.
- Providing technical support to consumers.
- Better and more suitable training of professionals, such as engineers, scientists, and researchers, who will develop new systems, devices, and technologies for the industry.

- Training of policy analysts who can study and improve the effectiveness of the policies and plans that governments establish.
- Training of people who will advise and help future customers of the industry.

Jennings's review demonstrates that firms that addressed these issues properly and invested in information and education have succeeded more than the companies that have ignored these needs.

Along with the increasing need, there have been several innovative developments in renewable energy education that focus on the gaps and needs of the industry. Some of these were mentioned above. In recent years, there have been several important initiatives in the field. Kendal and Broman reviewed the literature on renewable energy education initiatives around the world, the challenges met, and perspectives on the future [18]. They then formed a list of 12 practical recommendations for the relevant education programs. These are the key recommendations:

1. Concepts and courses on renewable energy should be introduced through all formal and informal stages of education. It is essential to guarantee both consistency and continuity in the education materials taught at different levels in order to maximize the efficiency and effectiveness of the renewable energy education strategy.
2. Renewable energy education programs must combine academic and practical aspects. The hands-on practical courses can include conducting laboratory experiments, demonstration operational systems, field visits, and field installation of systems. It is also possible to offer personal hardware-oriented projects as part of the programs.
3. Sufficient and adequate teaching resources must be provided as part of the program. They should include textbooks, laboratory manuals, and teacher guides for all levels and types of education, along with the hands-on skills training mentioned above.
4. The education programs should engage all of the members of the society as a whole. Everyone can and should be informed about the basic concepts of efficient energy use and the different renewable energy options available to them. This phase can include the use of mass communication media, relevant exhibitions, and more.
5. Organizing short courses, workshops, etc. is necessary, to ensure that the knowledge and skills of the teachers and, in accordance, the professionals are updated regularly.
6. The primary goal of any educational program is to prepare the population for the future and promote the use of renewable energy. Therefore, it is important to assess the current education programs and training needs to understand the societal needs of the future. Renewable energy education must be taken seriously, as its current level is far from satisfactory.
7. Guidelines and standards regarding university-level academic programs should be established so they can be a system of accreditation and standardization
8. Quality education is essential to tackle common issues, and unlike many other solutions, it can serve as a long-term solution. It is crucial to educate children at young ages, as these years shape one's perspectives and have long-term effects on their behavior. Along with that, educational programs can promote the usage of new technologies, thereby achieving the implementation of new renewable energy technologies.

2.1. Israel

Israel can produce a substantial amount of electricity using either large, utility-scale solar power plants or small, distributed solar power systems. For solar power stations to work, large tracts of land are needed and the power grid might need to be upgraded. On the other hand, distributed production using PV panels on rooftops does not require these procedures, while still having the advantages of the omnipresence of insolation [19]. However, it requires an assessment of the available rooftop area in Israel to make sure sufficient rooftop area is available.

A former analysis that was performed in cooperation with the Land Development Authority of the Jewish National Fund ("Keren Kayemet le-Israel"), based on data from 2007, concluded that PV electricity can generate 32% of the national electricity consumption in Israel [20]. With the rooftop area available, a total capacity of 12,000 MWp can be installed, which is more than the total installed capacity worldwide (7800 MWp in 2008) [21]. These findings can have major economic consequences. Installing PV systems on large rooftops can help reach 7% of Israel's national demand. This result demonstrates that the vast capacity of PV systems can be installed on rooftops as an alternative for allocating vast tracts of land.

According to a report by the Israel Ministry of Energy, there has been a significant rise in energy consumption in Israel in recent years, which highlights the need to improve consumption and shift toward sustainable and renewable energy consumption. The activity of the Ministry of Energy in general, and the energy conservation department in particular, has changed in light of the current needs: the energy conservation department declared that they are focusing on reducing energy consumption and reducing greenhouse gas emissions as a reaction to the climate crisis and rapid urbanization processes.

In 2015, similarly to other governments, the Israeli government established a national action plan to reduce gas emissions, which was eventually approved in 2017. This plan was based on the Energy Sources Law, and the relevant regulations made by the Israeli government over the years. It is a five-year plan and includes extensive changes in many sectors. Moreover, the ministry of energy published a 10-year plan for 2020–2030 which includes the private and the public sectors and aims to reduce energy consumption.

Forming the plan included several stages: first, the ministry updated the measures and the national goal of improving energy consumption and making it more efficient. Unlike the previous goal, the new goal not only focused on reducing electricity consumption, but also on reducing all energy consumption from all sources used in the economy. This goal goes along with the goal of renewable energy reaching 30% of the total energy consumed by 2030, similar to the goals set by the European countries mentioned above. The second stage included the conducting of a thorough analysis of the energy economy, including the recent trends in the various sectors. Finally, relying on the findings of the analysis and the conclusions made during the process, the Ministry of Energy recommended policy changes and budgets to promote them in the five years that followed. More specifically, the plan has six aims/goals: the national goal of improving energy intensity, energy savings (compared to previous steps of the plan), efficiency in the public -commercial sector, efficiency in the domestic sector, efficiency in the industrial sector, and efficiency in the transportation sector. Each measure was described in detail.

So far, there have been some changes in the energy consumption in Israel: between 2013 to 2017, the overall energy consumption has risen by about 10%, while the total gross domestic product has risen by about 14%. The energy intensity has been reduced by just about 3.7% [22]. A qualitative analysis of the factors that inhibit the improvements suggested that there are several main factors: using electric devices of low energy efficiency, limited importance of energy consideration in the commercial-public sector, limited planning of energy sources at a sector level, and finally lack of public awareness. The first three influence mostly the commercial, public, and industrial sectors, but the last factor affects all sectors. Lack of public awareness inhibits the efficiency of the entire market and each of the sectors involved, and its influence is highly notable in each of the other factors that were identified in the analysis [22].

For the different sectors to be more efficient, they must be aware of the financial potential and the environmental importance first. These days, energy consumers in the different sectors are simply unaware of the financial potential that reducing energy consumption has. Additionally, it is likely that the public is not aware enough of the environmental importance of reducing energy consumption. It is highly notable in the energy consumption in the domestic sector, which has risen between 2013 and 2017. Without raising awareness, it will be impossible to make the public change their consumption habits and lead to long-term projects.

As mentioned above, many countries have set goals and established plans to become more effective and reduce energy consumption. Therefore, they have incorporated education programs and broad campaigns to raise awareness. For example, in 2016, the German government launched a campaign for energy efficiency measures to encourage consumers, companies, and public institutions to become more efficient. The campaign was broadcast on many different platforms, including posters, commercials, websites, and more.

A few similar initiatives have been formed in Israel recently:

- "Energia Berosh Aher" (Energy with a Different Mindset)—an educational program for elementary school and junior high school. About 900 schools took part in the program between 2013 and 2015. The initiative includes a website with the same name, that offers digital modules, lesson plans, quizzes, and simulators on various related topics (e.g., daily usage of electricity and its consequences, how to use energy wisely at home, and the grading of the energy consumption of electronic devices).
- Kits to implement scientific and technological principles, to encourage behavioral patterns that promote energy-saving and efficiency. The kits provide an active experience with various technological mechanisms and allow for the investigating and solving of energy-related problems. Seven hundred schools received the kit between the years 2015 and 2019.

In the next five years, the ministry plans to broaden its digital platforms and to continue developing the website and providing teachers with online education tools. It will also invest in developing new kits for pupils which will allow them to experience energy saving on their own. Finally, the educational programs mentioned above will be extended, through educating and tutoring teachers, developing classes, supplying online tools, and more. The budget for these steps is estimated at 10 million NIS (about 3.05 million USD).

2.2. Publicity and Raising Awareness

The Israeli ministry of energy has led a few campaigns in recent years to raise awareness of energy consumption at home:

- Campaigns: between 2016 and 2019, two campaigns were running to raise awareness of energy efficiency, focusing on energy consumption in households and energy efficiency. The two campaigns are estimated to cost about 1 million NIS (about 310,385 USD).
- Raising awareness for energy efficiency: the ministry collaborated with several organizations to run two campaigns to raise awareness in the various Israeli sectors and companies.

In the next five years, the ministry plans to launch campaigns on different platforms (TV, radio, social media)–a vast long-term action which aims to change the consumption habits and behaviors of households. The campaigns will focus on changing consumption habits, raising awareness of the upgraded regulation of electric devices, encouraging the public to take part in education programs about energy, and more. These campaigns are estimated to cost 20 million NIS (about 62 M USD).

While many countries met and even exceeded their goals, Israel is left behind and has met none of the goals set yet [23]. The original goal, announced in 2015, was that by 2020, 10% of the electricity generated will be produced by renewable energy. However, by the end of 2020, the percentage was only 5.7. In 2021, it reached 7.5–8%, which is still highly disappointing. The low numbers for 2021 mean that there is great doubt regarding the chance of meeting the other targets set by the state, including the interim target for 2025, according to which 20% of electricity consumed in Israel will be generated from renewable energies, in addition to the target for 30% renewable energy by 2030. Therefore, even though there is positive progress, Israel is lingering behind all countries mentioned above. It is time to consider improving the current programs and adding alternative ones (Roe, 2022) [23]. In The "Green Ambassadors in the Community" course, we hope to increase elementary school pupils' awareness as part of a shift in thinking. This change will be aimed at affecting graduates, extended families, and the entire community.

3. Materials and Methods

3.1. The Course

HIT Holon Institute of Technology has been offering a course called Green Ambassadors in the Community since 2017. In the course, HIT's students learn about environmental issues and solutions, and then pass on their knowledge to elementary school pupils. Its ultimate goal is to turn the pupils into "ambassadors" at home, advocating for embracing green technology and environmental thinking, thus helping to shape public opinion. The course began in 2017 at Revivim Elementary School in Holon, a secular school. The school operated in Ramla's Arab school Al-Omaria in 2018. In 2019, the course was offered at the national-religious school in Holon, as well as at the Arab school in Lod called Neve Shalom. The course was also held in Holon, Israel, in the ultra-orthodox (Haredi) schools—the boys' school Bnei Menachem and the girls' school Bnot Menachem. In previous years, the course was conducted in schools in Holon, Lod, and Ramla due to logistical limitations of time and transportation. Lod and Ramla are neighboring cities to Holon, where the academic institution is located. Since 2020, the course was under the limitations of COVID-19, and since it was taught online, it could be done in more remote places. It took place in the Ben-Atar religious school in Dimona in 2021, and the Yitzhak Sadeh public school. In 2022, there are fourth- and fifth-grade pupils taking the course from the orthodox (Haredi) Shalhavut school in Gedera. Shalhavut school has two classes for each grade, a boys' class and a girls' class. This school was chosen based on a recommendation from a supervisor of the Israeli Ministry of Education who had heard of the course's success in the past.

The "Green Ambassadors in the Community" course combines activity and social involvement. There was both a theoretical component and a practical component in the course. In the first part of the course, the students learned about a variety of environmental topics, such as ecology, electricity generation, energy efficiency, renewable energy, waste, and recycling. The students also learned teaching methods and how to make a lesson plan. In the second part of the course, the practical part, the students taught fourth- and fifth-grade pupils at the Shalhavut school in Gedera. The course emphasizes learning through experience, and as such, the pupils learned about the environmental topics through experiments, demonstrations, and interactive trivia games.

3.2. Method

The following is a detailed description of the course sessions, experiments, and kits. Table 1 describes the composition and content of the kits.

3.2.1. First Session

The "Disappearing Styrofoam" Kit & the Bean Kit

The session opened with a Kahoot questionnaire, aiming to assess the pupils' knowledge and understanding of waste and recycling issues. The theoretical part included teaching the concepts of air pollution and water and soil pollution. Material depletion time was the next topic, which aimed to demonstrate to the pupils that when waste is thrown on the floor, it takes a long time for it to decompose, and it causes heavy pollution. The students performed with the pupils a short experiment named "The Vanishing Styrofoam", using Styrofoam. The students screened a video showing a Petri dish with a block of Styrofoam, into which acetone was poured. When the Styrofoam made contact with the acetone, it dissolved and transformed into liquid. The session enabled the students to understand that substances such as Styrofoam leave an eternal footprint, and even if they are melted (like the Styrofoam was melted into acetone), they do not disappear, they only change form.

Next, the students and pupils performed an experiment together named the "waste separation" experiment. In this experiment, sand and Styrofoam flakes were mixed in a transparent bowl, with the sand representing soil. Two possible ways to separate the Styrofoam from the sand were demonstrated: filtering with a strainer, and adding water to the mixture. The pupils learned that filtering is possible because the particle sizes of the sand and Styrofoam are different, hence when they were filtered, the sand passed easily through the strainer, while the Styrofoam did not. The second method involved adding water to the mixture, and the students saw how the water separated the layers so that all the Styrofoam flakes were in the top layer, and the sand settled at the bottom.

Table 1. Materials—Experiment kits.

Experiment Name	Equipment
The "Disappearing Styrofoam", kit	• 1 petri dish • 1 Styrofoam ball • Acetone bottle
The "Waste separation" kit	• 1 transparent bowl • 1 bag of sand • Styrofoam flake bag • Bottle of water
The bean kit	• 2 red stickers • 2 green stickers • 2 paper bags • Planting soil • Plant soil contaminated with bleach • 4 bean seeds • 1 trial report • 2 disposable spoons
The Thermos Insulation Experiment	• 2 test tubes with a volume of 15 mL • 2 test tubes with a volume of 50 mL • Cotton/chopped sawdust • 2 thermometers
the "Kettles" Experiment	• 2 kettles • 1 blue sticker • 1 red sticker • Timer • Bottle of water • 250 mL glass • paper and pen
The formation of the carbon dioxide experiment	• Balloon • A teaspoon of baking soda • Vinegar • Tube

This experiment led directly to the third topic, which was waste separation. The main idea was that instead of conducting a separation as demonstrated, it is possible to separate household waste by sorting it into the appropriate bins. The students exhibited the different trash bins that are used in Israel to classify and separate household waste.

Towards the end of the session, the students and pupils conducted another experiment together, which was followed by observation at home and writing a report on an experiment page. The kit included one bag with clean soil (marked by an emoji) and another bag with contaminated soil (soil that contained bleach in it—marked by an X), and the experiment was performed as follows: marking the two Petri dishes with green and red stickers, for the clean soil and contaminated soil, accordingly, and placing the appropriate type of soil on it. After the two Petri plates were filled with the appropriate soil, the students put the beans on top of the two types of soil and were asked to keep it in the light and not water it excessively.

Figures 1–3 demonstrate the bean experiment.

Figure 1. The pupils get the experimental kits.

Figure 2. The pupils during the bean experiment.

Figure 3. The bean experiment. The left Petri dish contains contaminated soil, and the right Petri dish contains clean soil.

Figure 4 shows a pupil filtering water.

Figure 4. The pupils while preparing a filter treated with contaminated water.

3.2.2. Second Session

The session opened with a discussion and questions about the bean experiment performed in the previous session. The pupils were asked various questions, such as which ones were able to grow the bean, and whether it grew in the Petri dishes. It was evident that the pupils nurtured the bean plant and were aware of the differences between the two dishes. The discussion helped convey the main message, which was that it is important to keep the environment clean, as it affects the plants and crops. After this the pupils learned about the processes that happens when it rains, and about groundwater. They were also introduced to water consumption in Israel. The students and pupils discussed the home use of water and the use of water in industry. For example, a discussion was held about the average family consumption, the amount of water needed to grow one banana, and the amount of water needed to produce a ton of paper.

The students also learned about the drinking water in Israel, including the Kinneret, also named the Sea of Galilee. The Kinneret is a freshwater lake in the north of Israel. In the past, it supplied most of the country's drinking water, and the country heavily depended on it. Currently, the Kinneret only needs to supply approximately 10% of Israel's drinking water needs thanks to major desalination activity.

3.2.3. Third Session

The Thermos Insulation Experiment

The third session was opened with a follow-up and a summary of the results of the bean, ward, and repeating of the primary messages and conclusions. The pupils then learned about the concepts of renewable energy and biodegradable energy (energy that disappears and is difficult to reproduce). Coal and oil were used as an example of biodegradable energy, as they are very common in many sectors, and the process causes air pollution.

Next, a discussion was held about wind energy, how it was used in the past and how it is used today. The purpose of understanding these processes and energy were not clear to the pupils. However, they were able to understand the advantages it has, including costs (the wind does not cost money), less pollution (the process does not pollute the environment), etc. The pupils became more aware of renewable energies and their purposes, which are to increase efficiency and reduce waste. Even the pupils that did not understand the process were able to understand the thought behind it.

After a short break, the kettles experiment was performed: the students took one kettle and filled it with two cups of water, then took a second kettle, and filled it with four cups of water. The pupils were asked how long it would take for each one to boil compared to the other. The students then boiled the kettles and used a timer to see the time differences. The message of the experiment is that it is better to fill the kettle according to the amount of water needed, and no more, since the less water that is used, the less time it will take for the water to boil. The pupils understood that less energy is consumed, less electricity is used, and this means energy efficiency. After that, the pupils discussed the concept of energy efficiency and other possible solutions for it, such as transportation (for example, using a bicycle or public transportation instead of a car).

Next, a video was screened explaining the difference between an LED light and an incandescent bulb. It was explained that an LED bulb is more energy-efficient, so it is best to use it. At the end of the session, it was explained to the pupils how the home water heater works. Afterwards, each pupil was invited to perform an experiment of thermos insolation in their home, with the help of their parents or older siblings. For this experiment, they were told that they needed to use hot tap water and not boiling water. They were instructed to fill the small test tube and wrap it in a cotton swab, and then to measure its temperature. After a while, they were to open the insulated test tube again, measure the temperature, and record the results. Then they were to do the same without the cotton swab and record the results. The goal was to get them to conclude, together with their parents at home, that the insulated test tube insulated heat better.

3.2.4. Fourth session

The Formation of the Carbon Dioxide Experiment

The session opened with a discussion and summarizing of all the past lessons and sessions, then followed with a brief experiment on creating carbon dioxide by the fermentation of baking soda and vinegar. The pupils used a balloon over the test tube and watched it explode as part of a reaction. It was explained to the pupils that carbon dioxide is heavier than air and cannot be seen or smelled. In addition, they were introduced to the idea of air monitoring stations and how the air quality level can be determined.

At the end of the session, the pupils stated that they were open to the presented ideas and understood that electricity could be generated from a variety of methods. They were not "intimidated" by electricity coming from a solar panel or a wind turbine.

4. Results & Discussion

In order to measure the effects of the "Green Ambasadors" course, including the theoretical and the practical parts, the pupils participated in a "Kahoot!" trivia game at the beginning and at the end of each session. The results demonstrate a successful learning process. The pupils absorbed the information through the activities of the lessons and their success rate of each "Kahoot!" trivia game was improving during the course.

The figures below show the results of the "Kahoot!"trivia sessions that were performed with 86 pupils from the Shalavut school in Gedera, Israel.

When asked what could be used as an energy source, at the beginning of the course 52 pupils responded oil (petroleum) and coal only. Eleven pupils responded that gas can be used as a single source of energy generation. Thirteen pupils chose the answer of wind and water and only 10 students responded that all the options are correct. At the end of the course, after being exposed to energy generation options from renewable sources, 44 pupils chose the correct answer, demonstrating their understanding of energy generation processes from different resources, including fossil sources such as oil, coal, and gas, as well as renewable sources such as solar, wind and water (see Figure 5 below).

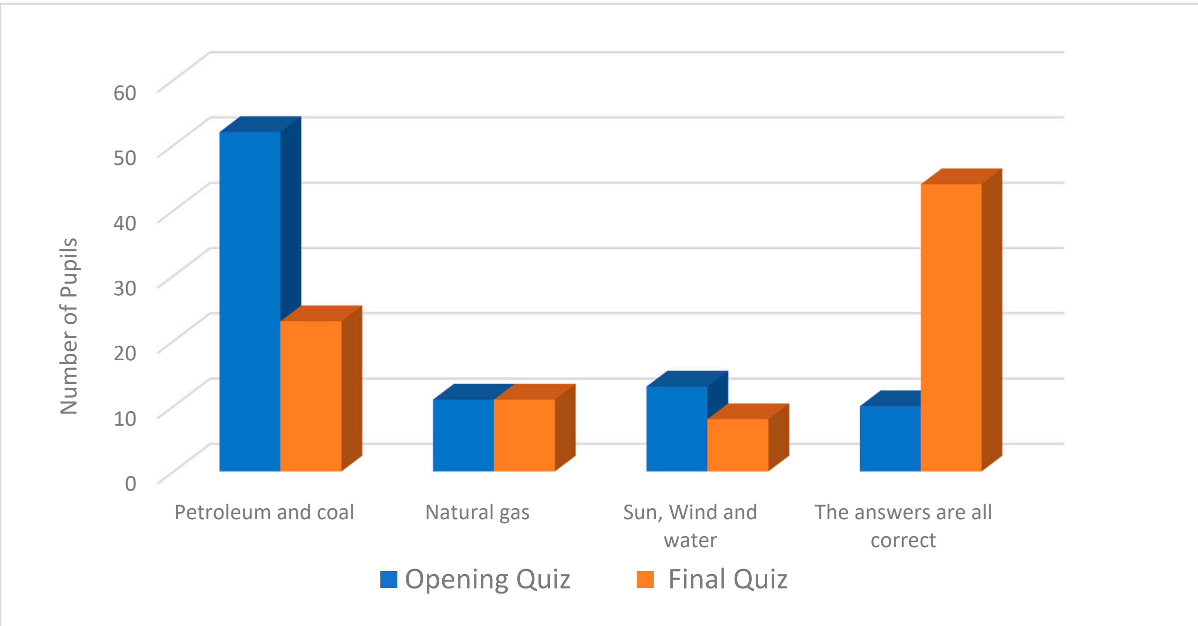

Figure 5. Results for the question "which of the following can be used as a source of energy?".

When the pupils were asked "Where is electricity produced in Israel?" at the beginning of the course, there was a similar segmentation between the answers: 20 pupils responded that electricity is produced only by the shore, 18 pupils thought that electricity was produced only in the Negev, 22 answered that electricity is produced in the valleys, and 26 pupils knew the correct answer, which is that electricity is produced in various places in the country. During the course, the pupils learned about a variety of power plants and a variety of energy production options. At the end of the course, 47 pupils knew the correct answer (see Figure 6 below).

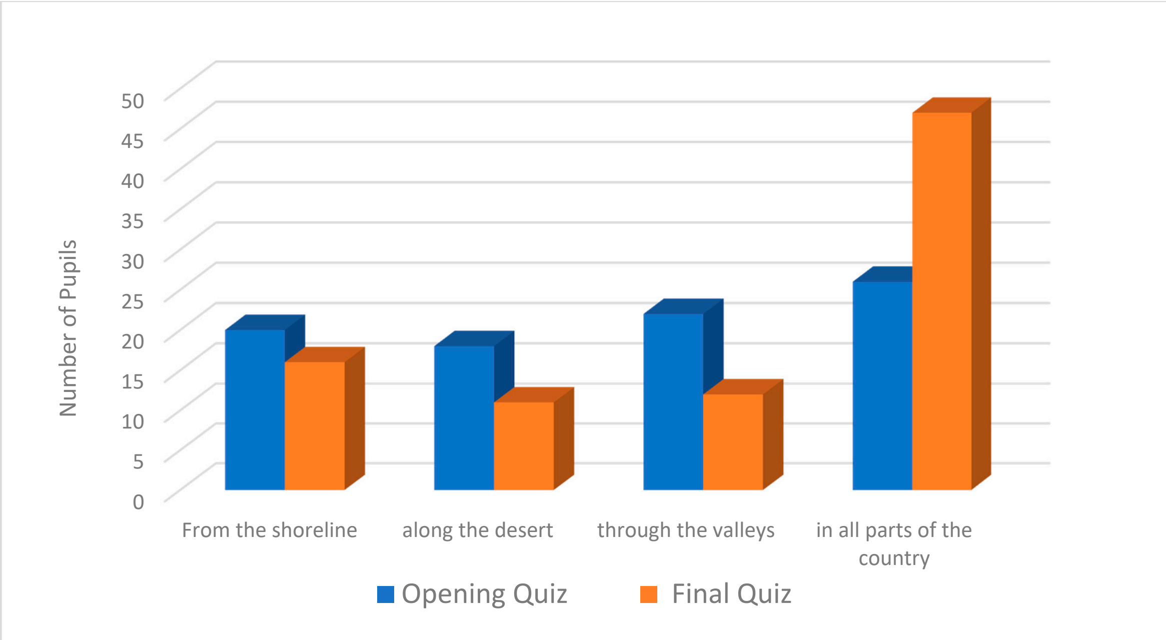

Figure 6. Results for the question "Where does electricity come from?".

The next question was "Who can generate electricity in Israel?" Prior to the course, most of the pupils (39) thought that only the IEC (Israel's Electrical Company) could generate electricity. During the course, the pupils were exposed to the various options for energy production and electricity generation and the great availability that exists in local electricity production. At the end of the course, 44 pupils responded that an energy producer is anyone who has the appropriate means to do so, and it is not dependent on the amount of consumption or place of residence (see Figure 7 below).

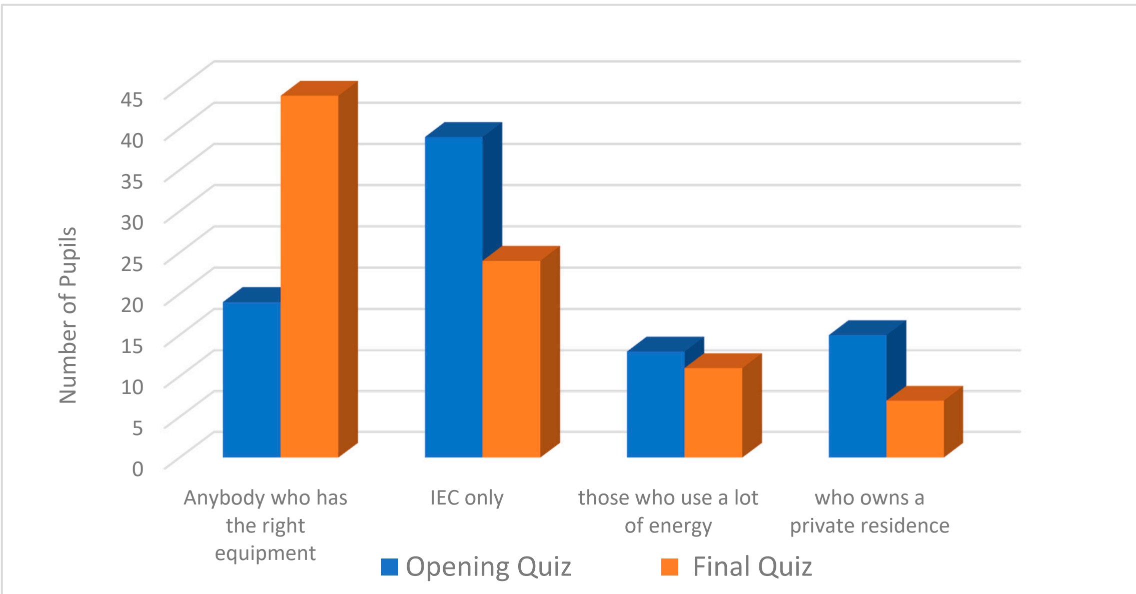

Figure 7. Results for the question "Who is capable of electricity generation?".

When the pupils were asked to complete the sentence "distributed energy systems are _", the answers varied: 22 pupils thought that these are systems that create energy in one central place, and supply energy to different and remote places. Twenty-eight pupils thought that these are energy creation systems in several places, and provide energy to different and distant places, while 28 pupils thought that energy consumption is located near the coal or oil burning site, and only eight pupils responded that a distributed energy systems are systems to create energy, in which the creation takes place simultaneously in several places, in several ways, and that in all of them the energy consumption is done near the place of creation. At the end of the course, after the relevant content was learned, most of the students (about 33) understood what a distributed energy system is (see Figure 8 below).

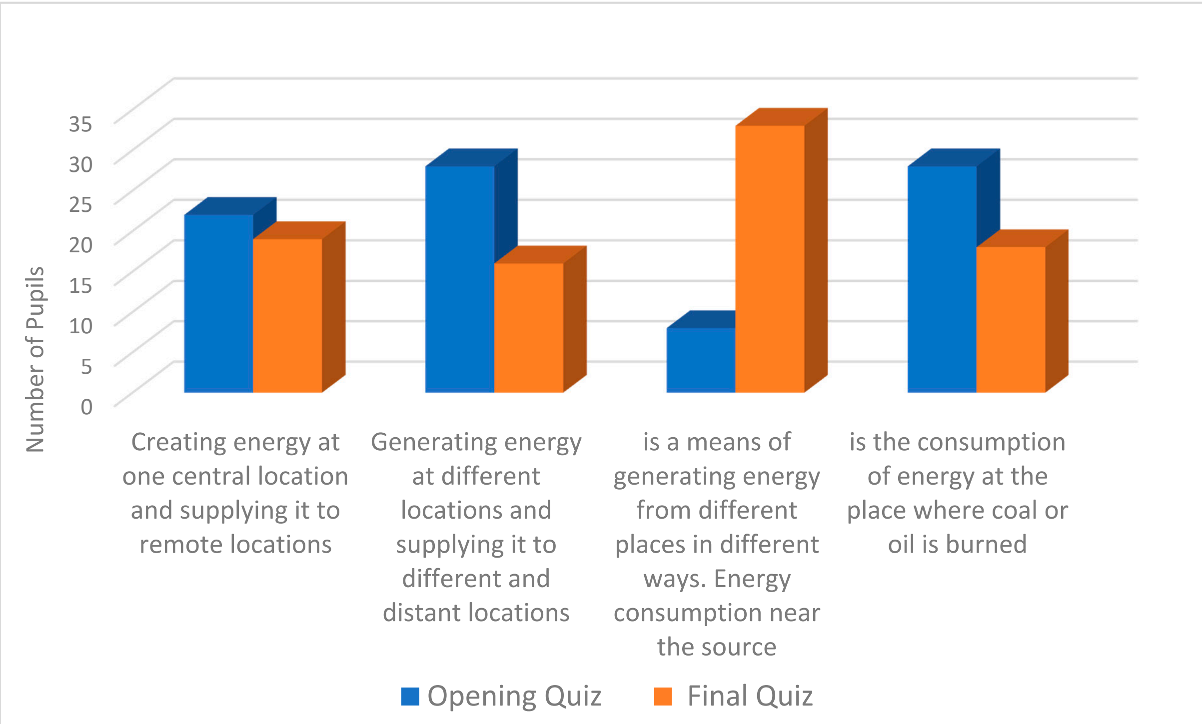

Figure 8. Results for the question "distributed energy systems are __".

5. Conclusions

When examining the answers to the questions before and after the course, we see that the content and teaching methods of the course provided the students with new knowledge, and improved their knowledge of the subject considerably. We can conclude that the course is valuable, as the pupils understood the content, and understood what renewable sources and distributed systems are. We hope that the pupils, as the next generation, will share their new knowledge with their family, friends, and their entire community, thus shaping public opinion to make the necessary changes to the energy economy. The results are in line with our previous findings and provide additional and strong support for the importance of the "Green Ambassadors" course [24–26]. It is widely and globally understood that distributed energy systems and using renewable energy are important and needed. To accomplish the goals mentioned above, we must focus on education. "The Green Ambassadors" course was shown to have an effect on the pupils, and we believe similar programs should be run for younger and older populations as well.

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