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Harnessing Neutrino Energy for a Sustainable Future

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ABSTRACT

There is a growing need for sustainable forms of renewable energy sources that are efficient, and cost-beneficial. Finding such energy sources is one of the critical challenges of the 21st century. This paper focuses on the prospects of using high energy particles abundant in the universe as a solution to the energy crisis faced around the world. The high energy particle studied in this paper is the neutrino.

Neutrinos are subatomic particles that are one-millionth the size of an electron ("How much does a neutrino weigh", n.d). They are of interest to physicists because they are present virtually everywhere, travel through regular forms of matter, and have exceptionally high energy levels ("What is a Neutrino", 1999). Neutrinos have ten billion electron volts when traveling freely across space, which is enough energy to break up the nucleus of an atom ("Neutrino Energies", n.d). Due to their high energy levels and eternal presence, neutrinos are a promising candidate for a renewable energy source. However, due to minimal reactions with other forms of matter, it is difficult to harness their intrinsic energies. A panel that is capable of absorbing neutrinos can potentially produce substantial amounts of heat energy, which can then be converted into electricity.

Energy from neutrinos is a great theoretical alternative and a clean source of energy for our planet and future generations to come. This paper takes another step forward in the mission to produce a primary source of energy that is green and sustainable for our planet.

Introduction

The challenges of climate change and global warming urge many nations to look at alternative sources of energy that are clean, non-polluting, and can last for the foreseeable future ("UN Climate Change", n.d). In other words, there is a need for sustainable forms of "Green Energy." Green Energy is derived from natural sources like the sun, water, and wind. (S.A. Rogers, 2019). These energy resources are renewable, meaning they are naturally replenished and are sustainable since their supply will continue to last. For the most part, the process of green energy production does not emit any greenhouse gases, pollutants, or toxic waste products. Technological advancements are continuously being made to make green energy more efficient and environment-friendly(S.A. Rogers, 2019). The scientific community is constantly researching and piloting new ideas on this forefront.

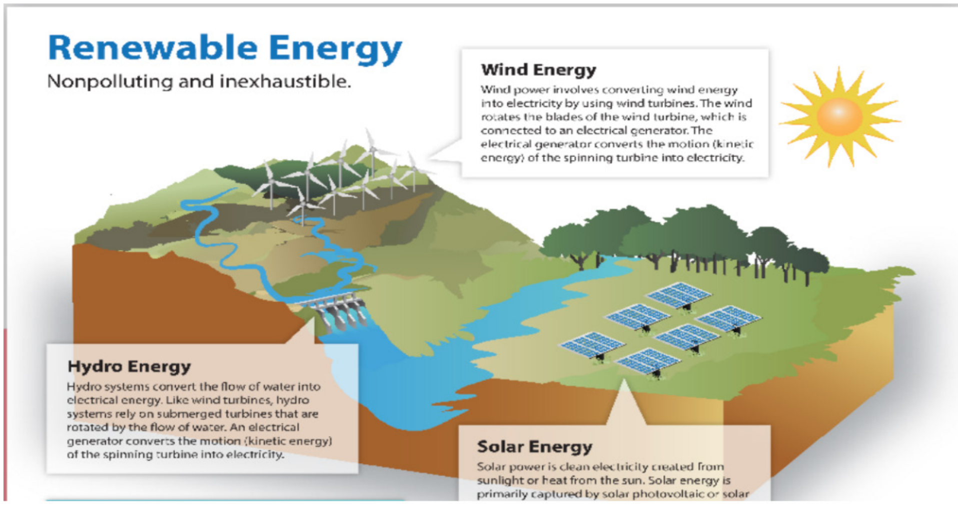

Figure 1. Introduction to types of Renewable Energy

About Neutrinos

Neutrinos have been a part of our universe since the Big Bang("Big Bang Neutrinos," n.d). They are high-energy particles categorized as leptons that don't carry charge ("What is a Neutrino", 1999). Neutrinos are known to be the most abundant particles in the universe, even more than protons ("What are Neutrinos", 2018). Three million billion neutrinos strike every square meter of Earth's surface ("Ghostlike Neutrinos", n.d).

Neutrinos have negligible mass because they are elementary particles, meaning that they don't comprise of other particles ("The Standard Model", n.d). They only interact with weak forces like gravity and electromagnetic force ("What's a Neutrino?", n.d), classifying neutrinos as leptons.

Due to these characteristics, a neutrino can easily travel through virtually everything in the universe without interacting with any matter in its path. Essentially, neutrinos whizz across space in straight lines nearly at the speed of light, traveling through every obstacle, be it stars, galaxies, or other cosmic matter (Yoksoulian, 2018).

Neutrinos were formed within seconds of the Big Bang, and continue to be formed in supernovas, radioactive decay, stars, and even in labs here on Earth (Orwig, 2012). Nuclear plants themselves produce about $5x10^{20}$ neutrinos per second, compared to the sun that produces $2x10^{38}$ neutrinos every second ("Finding the 'ghost particles' might be more challenging than what we thought", 2017). These abundant particles have (on average) about 10 billion electron volts of energy when traveling freely across space, which is enough energy to break up the nucleus of an atom("Neutrino Energies," n.d).

Neutrinos were first predicted in 1930 by Wolfgang Pauli and later detected in 1956 by Clyde Cowan and Frederick Reines, who received a Nobel Prize for their work in the field ("Neutrino", n.d). Neutrino research has gone a long way since, and we now detect neutrinos at facilities like the Ice Cube Observatory in Antarctica. The Ice Cube Observatory is a neutrino observatory designed to detect high energy neutrinos approaching from space. It detects about 100,000 neutrinos every year and is the world's largest neutrino telescope ("Ice Cube Quick Facts", n.d). However, the detection of neutrinos by The Ice Cube Observatory is few compared to the number of neutrinos present in the universe. This is because neutrinos barely interact with other forms of matter, making it difficult to be captured using the existing technology. Progressive research in this field should discover materials and technology that are capable of absorbing neutrinos.

Figure 2. Ice Cube Observatory, Antarctic

Neutrinos as a Sustainable Energy Source

The high energy of the neutrinos can be converted into other forms of energy if harnessed. The energy generated through this source will be a renewable form of energy because it will not impact the environment or the Earth's natural resources. The sun in itself produces 100 billion neutrinos every second, and other galaxies, stars, and cosmic matter produce neutrinos as well ("Solar Neutrinos", n.d). The stream of neutrinos will therefore last forever, making it a sustainable energy source for our planet.

Neutrino Panel

A theoretical Neutrino Panel can absorb the neutrino's internal energy, and the resulting heat energy due to the absorption can be converted into electricity. The conversion from heat energy to electricity can be done using heat-sensitive equipment like thermoelectric generators. The schematic diagram for the proposed Neutrino Panel is shown in Fig. 3.

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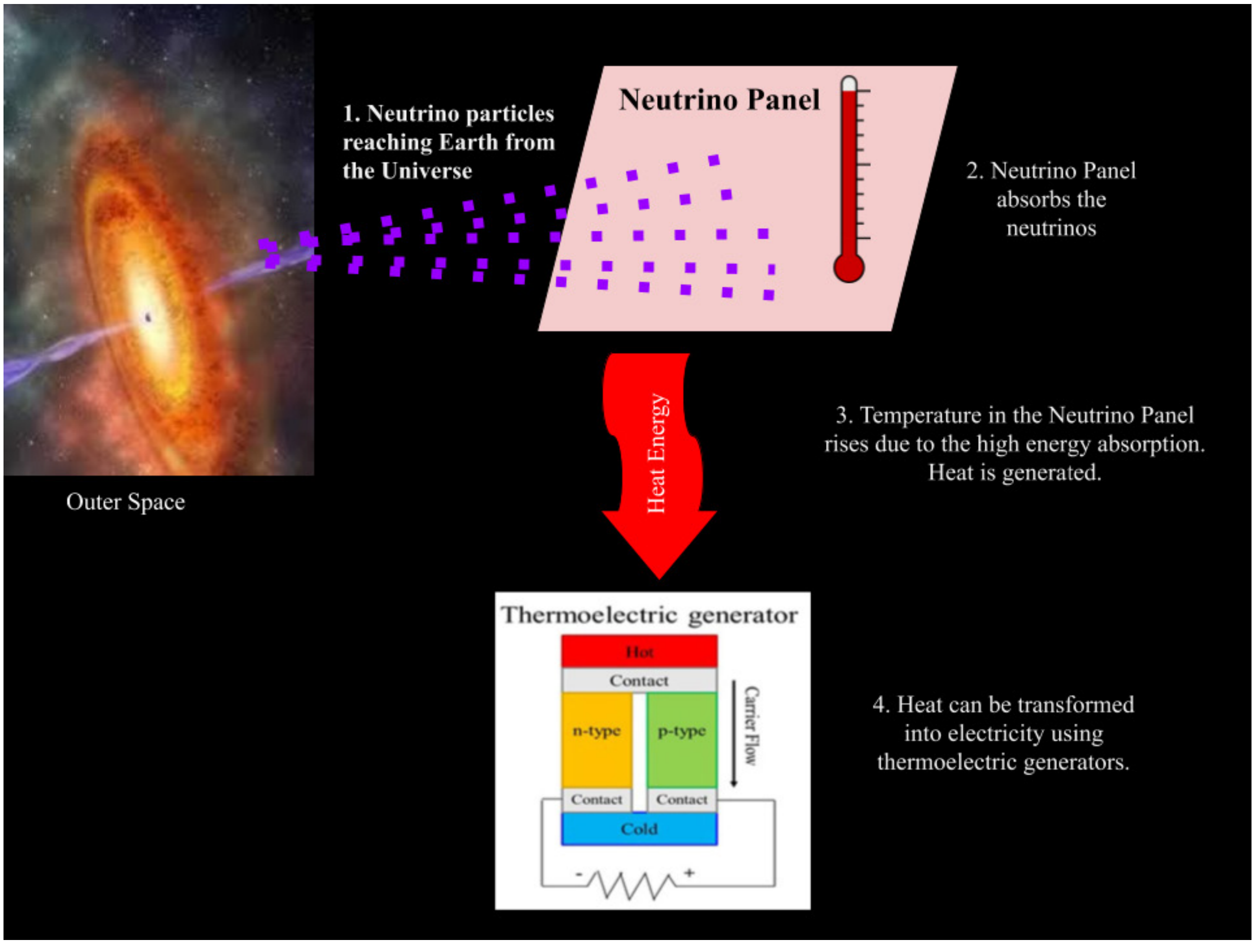

Figure 3. Schematic Diagram of the Neutrino Panel

Neutrino Panel - A Comparative Insight

Finding efficient and cost-friendly renewable energy sources is one of the main challenges of the 21st century. There are a few solutions present to address this challenge- these include solar power, hydropower, wind-power, geothermal power, and nuclear power. However, these solutions come with certain constraints.

1. They require specific geographical locations, such as locations with lots of sunlight for Solar panels, and high winds for wind-turbines.
2. They are expensive to install to generate power.
    a. Hydroelectric dams cost about $20 billion to build (Parshley, 2018).
3. They generate various amounts of power depending on the environmental conditions.
    a. Solar panels produce different amounts of power in different locations, even though the panel used may be the same (“How much output do you get from Solar panels?”, 2020).
4. They contribute indirectly to pollution

a. Toxic products are released in the making and disposing of photovoltaic cells, and they are not biodegradable (Shellenberger, n.d).

However, the proposed Neutrino Panel will not depend on geographical location, and it will not be constrained by environmental factors. Even though the panel is a theoretical idea where the costs of implementation are still unknown, the high efficiency will likely compensate for the implementation costs. Moreover, the energy generated by the panel will mostly be consistent since there is always a steady shower of neutrinos on the planet ("What's a neutrino", n.d).

Due to the high energy and geographical presence of neutrinos everywhere on the planet, Neutrino Panels can become the forefront of sustainable and renewable energy for future generations.

Neutrino Energy Efficiency Calculations

The data and the calculations shown below prove the energy efficiency of the Neutrino Panel. It supports the claim that a panel with a surface area of 454 m^2, after having absorbed neutrinos for a day, will have the capacity to power the city of New York for one day.

The following data forms the basis for the calculations :

1. Each of the 3 million billion neutrinos that strike every square meter of Earth's surface every second carries about 10 billion electron volts ("Ghostlike Neutrinos", n.d) (Bahcall, Serenelli, Basu, n.d).
2. New York uses 11 billion Watt-Hours in a day (Steinberg, 2012).
3. The most efficient Solar panel producing the highest wattage is considered for comparison of calculations (Powers, n.d) between Solar panel and Neutrino Panel.

The following assumption is made for the purpose of calculations: The Neutrino Panel has 100% absorption efficiency.

$$11\ \times 10^9 \frac{Wh}{day} \div\ 24\ hrs = 4.583\ \times 10^8 \frac{Wh}{hour}$$
$$4.583\ \times 10^8 \frac{Wh}{hour} =\ 2.86\ \times 10^{27} \frac{ev}{second}$$
$$2.86\ \times 10^{27} \frac{ev}{second} = \text{desired power}$$

Equation 1: $C \times N\ =\ S$where ;

C = Charge $_{\text{neutrinos}}$ = 10^{11} ev

N = number of neutrinos/second * cm^2 = 63 * $10^9/cm^2s$

S = charge/second * cm^2

$$\boldsymbol{(10 \times 10^9)\ ev\ \times \frac{(63 \times 10^9)}{cm^2 \times s} = 6.3 \times 10^{20}\ \frac{ev}{cm^2 \times s}}$$

$\boldsymbol{6.3 \times 10^{20}\ \frac{ev}{cm^2 \times s}}$**= Charge of neutrinos/second * cm^2**

Equation 2: $P =\ S \times A$ where;

P = desired power = 2.86 * 10^{27} ev / s

S = charge/second * cm^2 = 6.3 * 10^{20} ev/cm^2s

A = area of the panel

$$\mathbf{2.86 \times 10^{27}\ \frac{ev}{second} = 6.3 \times 10^{20} \frac{ev}{cm^2} \times area}$$

$$Area = \frac{2.86 \times 10^{27} ev\ /\ second}{6.3 \times 10^{20} ev/cm^2 s}$$

$$Area = 4{,}539{,}682.5\ cm^2 = 454\ m^2$$

These calculations prove that a panel size of $454m^2$, assuming 100% absorption efficiency, can generate energy to power the city of New York for one day. After a full day of charging the 454 m^2 panel, can generate about 11 billion Watt-Hours of power.

Next, the same calculations are performed to show the size of a Solar panel required to generate 11 billion Watt-Hours after being charged for a day. The Solar panel used for the calculations is SunPower 415, the most powerful solar cell in the world which generates 415 watts every hour (Powers, n.d).

11 billion Watt-Hours in a day = $4.583 * 10^8$ Watt-Hours/hour = $2.86 * 10^{27}$ ev /second

$2.86 * 10^{27}$ ev / second = desired power

1 SunPower 415 watt/hour Solar panel produces:
415 WattHours/ day

$$415\ \frac{WattHours}{Days} \times \frac{1\ Day}{24\ hours} = 17.29\ Watts = 17.29\ \frac{Joules}{second}$$

$$17.29\ \frac{Joules}{second} \times 6.242 * 10^{18}\ \frac{ev}{Joules} = 1.07\ \times 10^{20}\ \frac{ev}{s}$$

Size of 1 panel: $41\ in \times 62\ in = 16400\ cm^2$

Equation 3: $\frac{X}{Z} = Y$

X = power in ev/seconds the Solar panel produces = $1.07 * 10^{20}\ \frac{ev}{s}$

Z = 16400 cm^2

Y = power in ev/second * cm^2 the Solar panel produces

$$1.07 * 10^{20}\ \frac{ev}{s} \div 16400\ cm^2 = 6.58 * 10^{15}\ ev/second \times cm^2$$

1 SunPower 415 watt Solar panel produces $6.58 * 10^{15}\ ev/second \times cm^2$.

Equation 4: $P = Y \times N$ where ;

P = $2.86 * 10^{27}$ ev / second

Y = power in ev/second * cm^2 the Solar panel produces = $6.58 * 10^{15}\ ev/second \times cm^2$

N = total area of Solar panels

$$2.86 * 10^{27} ev/second = N \times (6.58 * 10^{15}\ ev/second \times cm^2)$$

$$N = \frac{2.86 * 10^{27} ev/second}{6.58 * 10^{15}\ ev/second \times cm^2}$$

N = $4.35 * 10^{11}$ cm^2 = $4.35 * 10^7$ m^2 of Solar panel

454 m^2 (Neutrino panel) < $4.3 * 10^7$ m^2 (Solar panel)

The results above show that the area of Solar panels (which is 43 million square meters assuming the best Solar panel in the industry) required to generate 11 billion Watt-hours in a day is far higher than the area of a Neutrino Panel (assuming 100% efficiency) required to generate the same amount of power in a day.

Limitations

The Neutrino Panel as explained in the schematic diagram in Fig.3 is a theoretical model. Building the panel to collect the experimental data was not possible in this research article because of the limitation that the materials that absorb neutrinos are yet to be discovered. The research to discover materials that are capable of absorbing neutrinos is underway. Once such discovery is made, it will open doors to possibilities to engineer, design, and build efficient Neutrino Panels, for a sustainable future.

Conclusion

The astonishing amounts of energy from neutrinos can be used to the greatest advantage, without affecting the Earth's natural resources. Even though the materials that can absorb neutrinos are yet to be discovered, future research in this field is crucial to understand the ways to capture the neutrinos. Since neutrinos have high energy and a universal presence, Neutrino Panels that harness this energy will become the forefront of sustainable green energy for the future.

Further Research

Further research in this field can include exploring and experimenting with materials that may have the ability to absorb the neutrinos. More possibilities include researching other potential structures and designs for the Neutrino Panel to validate its efficiency, challenges, and solutions.

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