

International School of Tomorrow

Is nuclear energy a good source of energy?

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Introduction

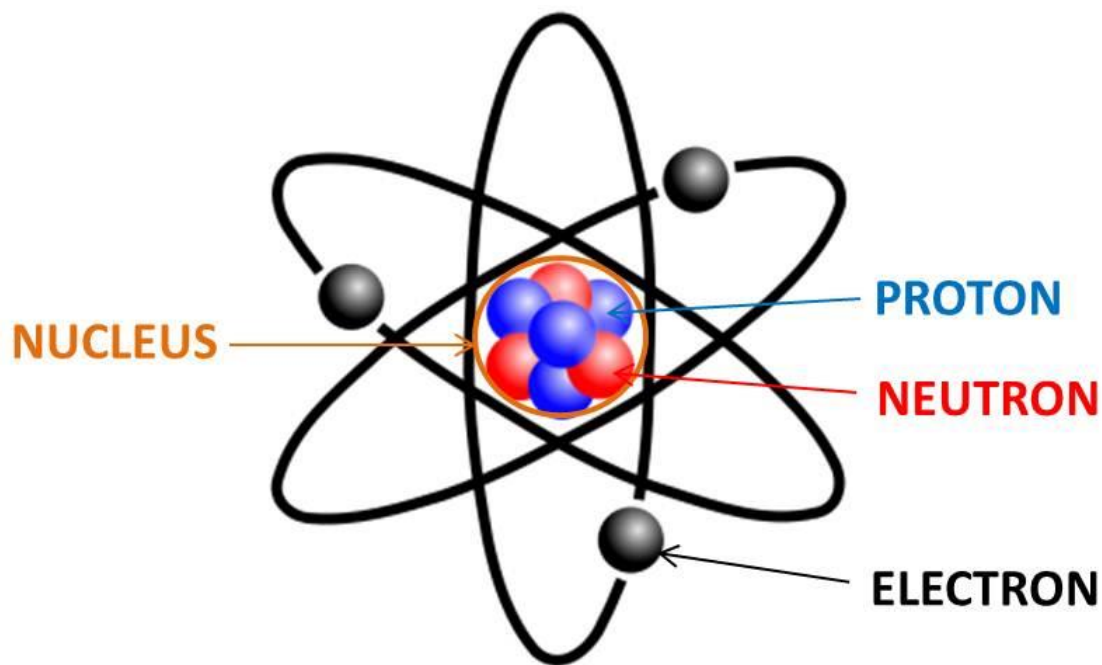
Currently, we are facing many crises, global warming and climate change being some of them. And one of the things that we can do to help our planet is a transition to a cleaner source of energy. And one source of energy that we can use is nuclear energy. In fact, many governments have building more nuclear power plants as a part of their plan to combat climate change. That is why I think now would be a good time to learn more about nuclear energy.

The goals of my final project are:

- To define nuclear energy
- To inform how it is obtained
- To search the advantages and disadvantages of nuclear energy
- To find out if nuclear energy is safe.

What is nuclear energy

So, what is nuclear energy? Nuclear energy is a form of energy released from the nucleus of an atom. Atoms are tiny units that make up all matter in the universe.

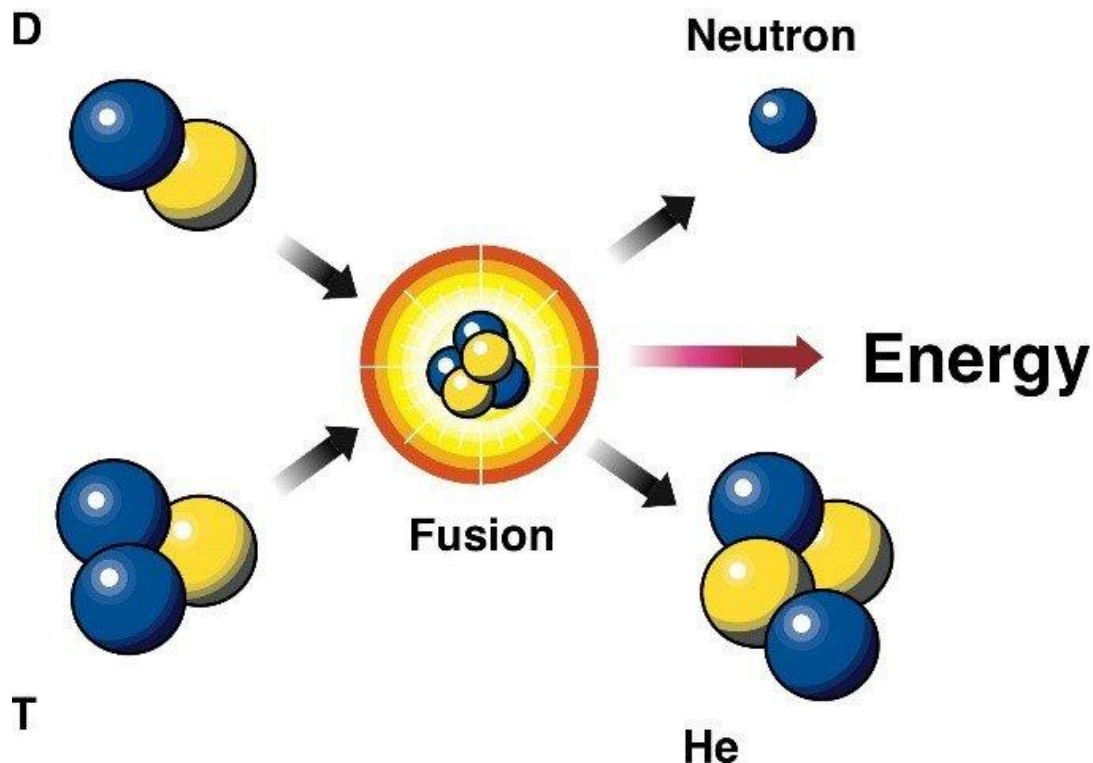


An atom is made up of electrons orbiting around a nucleus consisting of protons and neutrons bound together. The protons and neutrons are bound together by a huge amount of energy, called the “strong force”. This is where nuclear energy comes from. In fact, the word nuclear itself means “of the nucleus of an atom”, so nuclear energy can be understood as energy of the nucleus of an atom. Nuclear energy can be used to produce electricity, but it must first be released from the atom. There are 2 ways of producing nuclear energy: fission and fusion.

How it is obtained

A. Nuclear fusion

Nuclear fusion is the process by which two light atomic nuclei combine to form a single heavier one while releasing massive amounts of energy. Fusion reactions take place in a state of matter called plasma — a hot, charged gas made of positive ions and free-moving electrons that has unique properties distinct from solids, liquids and gases.¹ This reaction is what powers the Sun and other stars.



¹ What is Fusion, and Why Is It So Difficult to Achieve? | IAEA. (n.d.). <https://www.iaea.org/bulletin/what-is-fusion-and-why-is-it-so-difficult-to-achieve>

Fusion reactions produce about 4 times as much energy as fission reactions. Potential future fusion reactors will probably use mixture of deuterium and tritium — heavy types of hydrogen. A few grams of these reactants can potentially produce a terajoule of energy, enough for one person in a developed country in over sixty years.

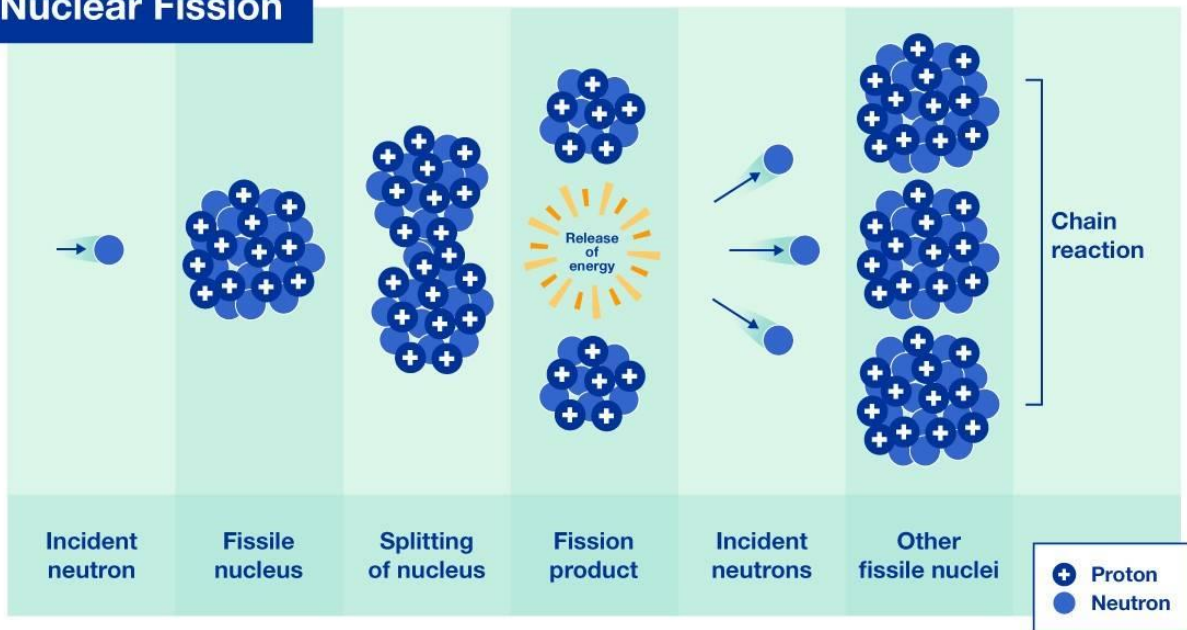
Unfortunately, scientist haven't found a way to turn this into commercial use. Currently, it cost more energy to conduct fusion experiment than fusion itself generate. They are working non-stop though, and just recently they had made a breakthrough on nuclear fusion. So may be in the near future we may see fusion-powered plant, but for now we will have to stick to nuclear fission.

B. Nuclear fission

Nuclear fission is the opposite of fusion. It is a reaction where the nucleus of an atom splits into two or more smaller nuclei, while releasing energy.² This usually happens when a neutron hits the nucleus of an atom, splitting it into two. The neutron can then go on to hit other nuclei, creating a chain reaction. As the atom split, energy is released in the form of heat and radiation. This heat energy is what nuclear power plants use to generate electricity. Every nuclear power plant in the world uses this reaction.

² What is Nuclear Energy? The Science of Nuclear Power. (n.d.). IAEA.
<https://www.iaea.org/newscenter/news/what-is-nuclear-energy-the-science-of-nuclear-power>

Nuclear Fission



Application of nuclear energy

As mentioned above, radioactive elements are used in electric generation. They are also used in many different fields for a variety of purposes. In medical, nuclear technology can provide images inside the human body (e.g., x-ray) and radiation can be used to kill cancer cells without damaging healthy cells. It is also used to sterilize medical equipment.

In food and agricultural field, radiation can be used to prevent harmful pests from reproducing. Irradiation can kill bacteria and other harmful organism in food without affecting their freshness nutritional value. Direct irradiation of food is a technique accepted and recommended by the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA).³

Isotopes and radiations are also widely used in industry. Almost all branches of science use them in different ways. They can be used to identify and assess the properties of different materials, measure pollution levels, change chemical, physical and biological properties materials, etc.

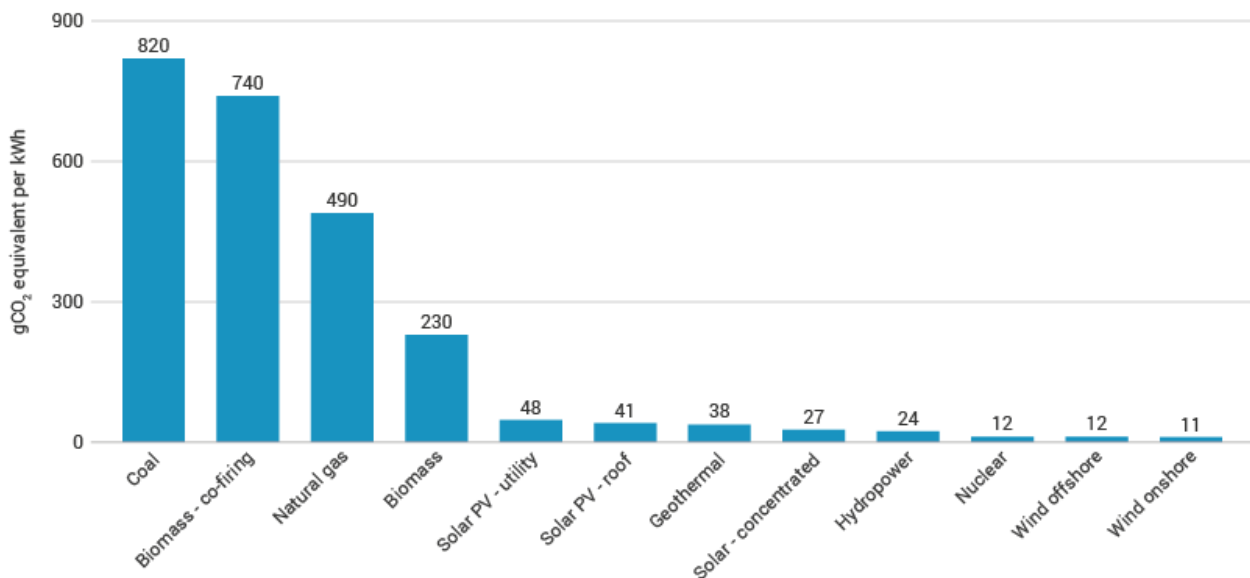
Other applications of nuclear technology include use in space exploration, art and history, criminal investigation, etc.

³ Applications of nuclear technology. (2020, June 3). Foro Nuclear. <https://www.foronuclear.org/en/sector-values/applications-of-nuclear-technology/>

Pros and cons of nuclear energy

A. The advantages of nuclear energy

First of all, nuclear energy generates a very small amount of CO₂. As shown in the graph below, nuclear energy produces as much CO₂ as wind energy, and less CO₂ than solar power. The mining of fuels, transportation and maintenance of a plant also produce little amount of CO₂.

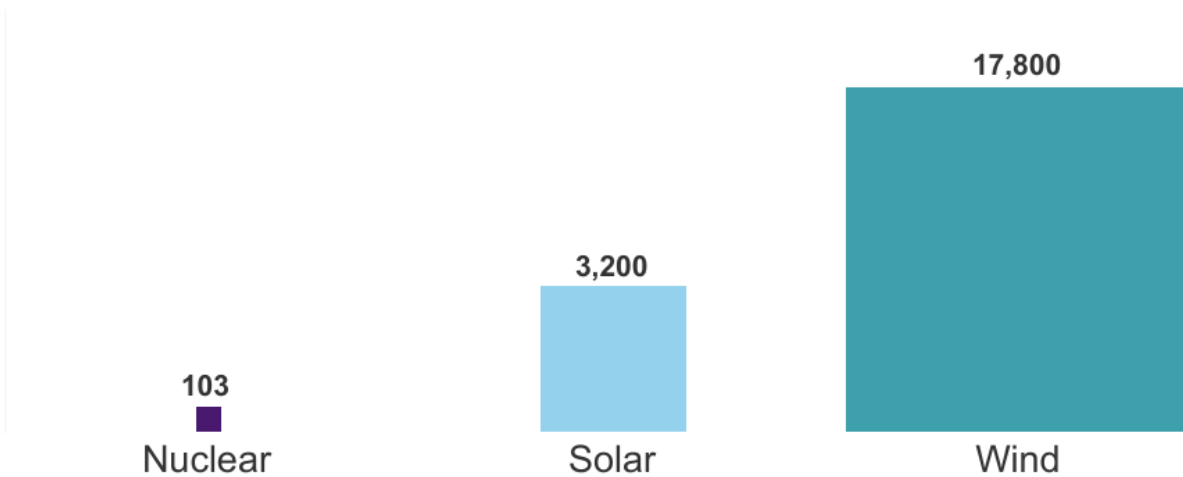


Nuclear energy is also very energy-dense. One kilogram of 4%-enriched fuel grade uranium releases energy equivalent to the combustion of nearly 100 tons of high-grade coal or 60 tons of oil.⁴ This means nuclear energy is very efficient with just a small amount of fuel. A nuclear reactor needs just about 27 tons of fuel each year, whereas a coal power station would require more than two-and-a-half million tons of coal just to produce the same amount of electricity.

⁴ Benefits of Nuclear Energy. Rosatom. <https://www.rosatom.ru/en/investors/benefits-of-nuclear-energy/>

Another advantage of nuclear energy is that it uses very little land. A typical 1000-megawatt nuclear power plant uses around 2 km² of land area per megawatts of energy. According to Nuclear Energy Institute, wind farms require up to 173 times as much land area to produce the same amount of electricity as a nuclear power plant. Solar photovoltaic (PV) facilities require up to 31 times the land area.

Land Use by Energy Source
acres per million megawatt-hours



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Source: 2014 U.S. National Climate Assessment, U.N. Environment Programme

Nuclear energy also uses less building materials. The amount of materials required to build a power plant is great, but if we look at the amount of energy generated per tons of material used, it is actually more efficient than other sources of energy.

Material tonnes/GWh/yr	Capacity Factor	Concrete	Steel
Nuclear	85%	43	8
Solar PV farm	20%	43	10
Wind – onshore	30%	159	43
Solar Thermal – 7.5 hrs storage	44%	338	105

B. The disadvantages of nuclear energy

Firstly, nuclear power plants are expensive to build. The design of power plants must comply with strict safety regulations. These laws make power plants safer, but at the same time, they make power plants more costly to build. A nuclear power plant can cost between \$5 - \$10 billion to build, and both renewables and fossil fuels end up being cheaper in terms of the initial investment.

Secondly, nuclear energy is non-renewable. Nuclear energy depends on uranium and thorium to produce energy, but these resources are limited. In 2011, experts surmised that the world's uranium supply would last 80 more years at the then-current rate of consumption. Since then, uranium output has generally risen, which means nuclear energy is a short-term solution, at best.⁵ This means we will eventually have to give up nuclear power, unless we are able to build fusion reactors before then.

Thirdly, despite its low CO₂ emission, nuclear energy still produces harmful radioactive waste. This waste is incredibly difficult to get rid of, and can remain radioactive for several hundreds of years. Nuclear waste after being spent is very hot, and is kept underwater for 5-8 years until the radiation levels decay to levels that can be cooled without water. After which they are either recycled, or moved into "dry cask storage". These casks are stainless steel canisters surrounded by concrete.

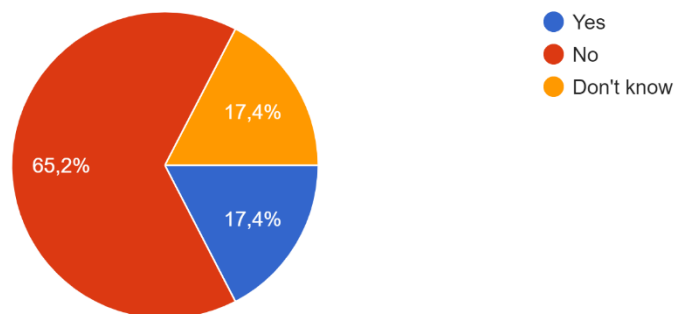
Lastly, the general public is afraid of anything nuclear related. This fear stems from several reasons, the first of them being nuclear accidents at Three Mile Island, Chernobyl, and Fukushima. These accidents frightened people and left doubts about the safety of nuclear energy. There's also a lot of concern about radiation. Many think that radioactive waste can pose a

⁵ Marsh, J. (2022, October 27). Nuclear Energy Advantages and Disadvantages. Environment Co. <https://environment.co/nuclear-energys-advantages-and-disadvantages/>

threat to the environment. I decided to make a survey to see what are the opinions of nuclear energy in this school.

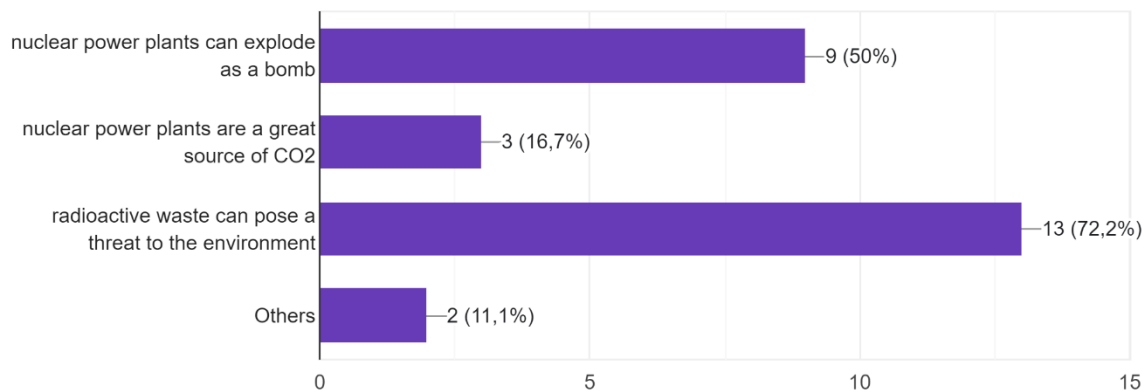
Do you think nuclear energy is a safe source of energy?(skip the next question if you chose yes)

23 câu trả lời



If your answer was no, it is because

18 câu trả lời



As shown in the survey above, the majority of people (65,2%) don't think nuclear energy is a safe source of energy, with the most common reasons being concern about radioactive wastes (72,2%) and meltdown (50%).

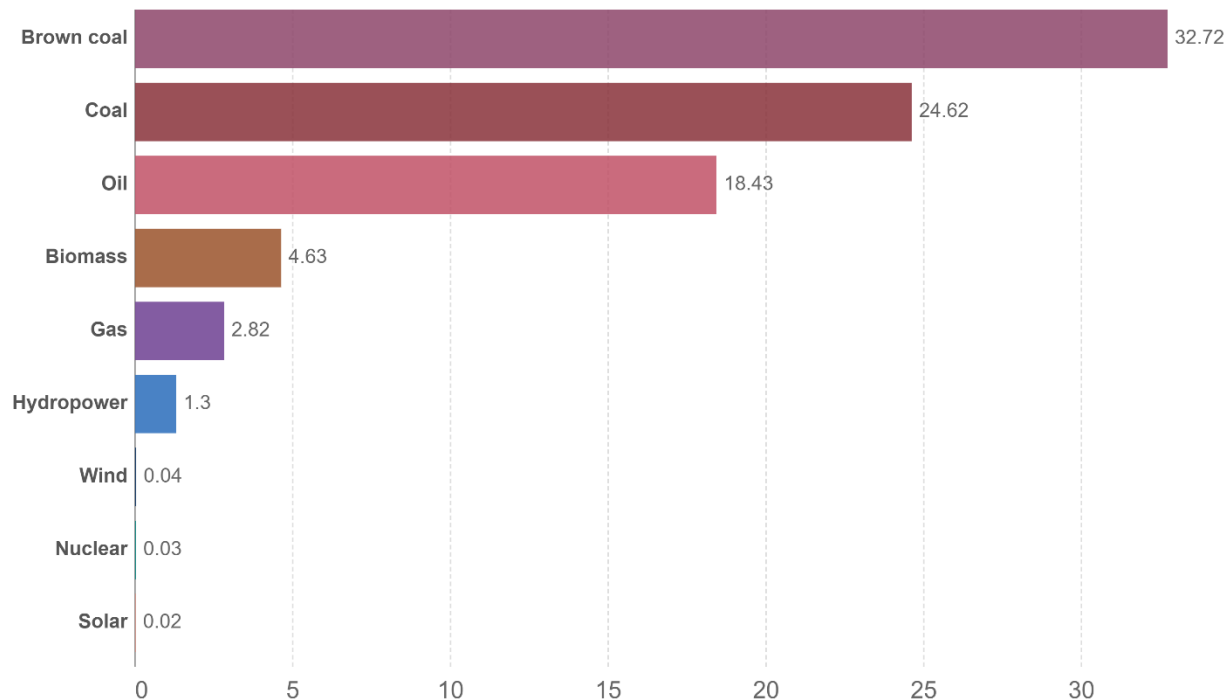
Is nuclear energy safe?

With all of that said, is nuclear energy safe? I would say yes because first of all, despite all of those concern about radiations, nuclear energy has one of the lowest death rate.

Death rates per unit of electricity production

Death rates are measured based on deaths from accidents and air pollution per terawatt-hour (TWh) of electricity.

Our World
in Data



Source: Markandya & Wilkinson (2007); Sovacool et al. (2016); UNSCEAR (2008; & 2018)

OurWorldInData.org/energy • CC BY

As shown in the graph above, the death rate per TWh of nuclear energy is comparable with solar and wind, even after the inclusion of accidents like Chernobyl or Fukushima. In fact, climatologists Pushker A.

Kharecha and James E. Hansen calculated that the use of nuclear power between 1971 and 2009 prevented the death of 1.84 million people.

Secondly, as mentioned above, accidents like Chernobyl or Fukushima caused little casualties. And we should look at these accidents in the context as to why they happened. In the case of Chernobyl, it happened because one of the technicians there attempted a poorly controlled experiment, which caused the chain reaction in the core to go out of control. It means that the accident happened because someone was attempting a stupid thing in the wrong place.

In the case Fukushima, a combination of tsunami plus earthquake disabled the power supply and cooling of three reactors, causing them to melt. But this power plant was a II-generation plant, and in fact there was another plant nearer the epicenter, but nothing went wrong because it was a III-generation plant better equipped against natural disasters. As you can see, as we learn from our mistakes and our technology advances, these type of accidents, which are exceedingly in itself, are likely to never happen again.

Finally, while nuclear waste is indeed radioactive, they are handled under rigorous safety regulations. Since 1970, there have been over 7000 shipments of used fuel just in the United States alone, but there have been no leaks of radioactive material, injuries or environmental damage.

Conclusion

I would say that nuclear energy is one of the best options for combating climate change and global warming. Despite having some disadvantages, I would say the benefits outweigh the risk, and it is definitely one of the solutions to climate change and global warming. As our technology progresses, nuclear technology can only get better and safer from here. I hope this paper gave you a better understanding of nuclear energy.

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