

2025 Science Exploration Fair- To do, To understand.

Form of Scientific Article- College/ Social Group

Title of the article: Oppression of a Safe Energy Source (Nuclear Energy)

Abstract: This article defends nuclear energy through scientific evidence of its safety, environmental benefits, and climate potential, while also refuting common misconceptions using updated technology and methodology.

Contents: (500 to 1,500 words limit)

For years, the topic of nuclear energy has sparked intense debate — not just within the scientific community (where discussions focused more on discovering it than suppressing it), but also through widespread public discourse. Concerns about environmental impact and human health, especially after the global disaster of the Chernobyl failure — and to some extent, Fukushima — were obvious reasons for the emergence of widespread skepticism and prejudice surrounding this energy source. But let's take an honest look and truly analyze the complete paradigm that nuclear energy presents.

First, electricity is generated by converting water into steam using the heat from nuclear fission (splitting the atom by a "neutron bombardment"), which spins the generator's turbines. The smoke coming out of nuclear plant chimneys is not CO₂ or any pollutant — it's just steam. In other words, we're polluting about as much as boiling eggs every day.

In terms of greenhouse gases, nuclear energy is considered non-polluting. According to the IPCC's scale, its emissions are nearly on par with wind energy, and far lower than fossil fuels. In fact, a 2022 update to that assessment showed nuclear emitting less than 15 g CO₂-eq/kWh, even lower than solar photovoltaic in some conditions. This, contrary to popular belief, makes it a viable — or at least provisional — source to combat climate change, especially against the thermal power plants that are leading contributors. In fact, a 2010 study by the U.S. National Research Council found that replacing the country's 100 nuclear plants with coal-fired plants in 2005 would have led to thousands of additional premature deaths annually due to air pollution. This highlights the critical role nuclear energy can play.

Environmentalists often oppose nuclear energy by citing the toxicity and radioactivity of nuclear waste. Yet even high- and medium-level waste poses minimal health risks when handled properly. There are specialized treatments and containers (ATIs), and active research to find optimal storage locations. Moreover, current reactors only extract 5% of uranium's energy. In the near future, fourth-generation reactors will extract over 90%, making waste less radioactive and requiring storage for only a few hundred — not hundreds of thousands — of years. As of 2024, several fourth-gen reactor designs (like molten salt and sodium-cooled fast reactors) are already in late-stage development in countries like the U.S., Canada, and China. Their ability to recycle existing nuclear waste into fuel marks a turning point in waste reduction and sustainability.

As for the impact on flora and fauna, look no further than the ecosystems surrounding today's nuclear plants. Modern technology, safety protocols, infrastructure, and training have drastically reduced the likelihood of leaks or failures. According to a 2007 Lancet study, nuclear energy causes fewer deaths from accidents and air pollution than most other energy sources — even when counting Chernobyl and Fukushima. Radiation emitted by functioning plants is even lower than normal environmental background levels. And in recent years, additional safety advancements such as SMRs (Small Modular

Reactors) have emerged as a breakthrough. These modular reactors are designed to be inherently safe, affordable, and deployable in diverse locations, including remote and developing regions.

Importantly, many renewable energy sources are heavily dependent on nature: solar requires sunlight, wind needs wind. Nuclear, on the other hand, uses atoms — which are everywhere — to produce large amounts of energy by releasing it from the nucleus. Experts view nuclear as the perfect complement to renewables — not a replacement, but a consistent partner unaffected by weather conditions. The International Energy Agency (IEA) stated in 2023 that tripling nuclear capacity by 2050 is "essential" to meeting net-zero climate goals. Even Bill Gates' company TerraPower is currently building a next-gen reactor in Wyoming that uses liquid sodium as coolant, promising passive safety and near-zero waste.

These are just some of the advantages supporting broader nuclear implementation. My goal is not only to clear up doubts and debunk myths, but to encourage a more positive view — and to help fight the ignorance that fuels fear, which in turn leads to unfair protests, plant closures, and blocked projects.

Notice that I've avoided discussing cost-effectiveness or the virtually impossible use of civilian nuclear energy in weapons. The real argument lies in its ecological benefits — which are urgently needed in a world desperate to replace coal, oil, and gas.

In the end, misinformation is the greatest enemy of progress — as clearly seen in this case. Many anti-nuclear activists are mentally anchored to past tragedies. Yet they often fail to understand these events in their historical and technical context, or to acknowledge the extensive improvements made over the years. This resistance, while frequently well-intentioned, can result in missed opportunities for climate action and sustainable development. It is important that such debates move toward informed consensus and open dialogue, rather than polarizing fear or ideology.

The political and environmental groups that oppose the advancement of nuclear energy may, sometimes inadvertently, reinforce the status quo — one still reliant on fossil fuels and their damaging effects. Rather than viewing nuclear energy as a threat, we should begin to see it as part of a larger toolbox of clean energy solutions. Reassessing its role in our energy mix is not just prudent — it is urgent. The time has come to reframe the conversation, foster evidence-based discussion, and recognize the potential of nuclear power to contribute to a more sustainable, resilient, and fair energy future.

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