DEMYSTIFYING NUCLEAR ENERGY

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Abstract: *Our article aims to dispel the myths and stigma surrounding nuclear energy and highlight its benefits over other alternatives. It focuses on three factors that people usually raise as concerns regarding nuclear energy: its high cost, its non-renewability, and the fear of it. The text argues that the fear of nuclear energy is mostly unfounded and has been reduced by improved safety measures and regulations. Furthermore, we are going to explain that nuclear waste is not as dangerous as people tend to think, and it is relatively easy to handle. Finally, we are presenting thorium as a promising alternative to uranium, although it acknowledges that there are still some economic and infrastructure challenges to overcome.*

Key words*: Benefits, cost, fear, non-renewability, nuclear energy, nuclear waste, regulations, safety, stigma, thorium.*

Introduction

Nuclear energy has always been a controversial topic, with many people being afraid of it and considering it too risky to use. However, our work argues that most of the concerns and fears about nuclear energy are unfounded and based on outdated or inaccurate information. The text aims to demystify nuclear energy and show that it is a viable and advantageous source of energy. To achieve this, the text will focus on three common concerns about nuclear energy: its high cost, its non-renewability, and the fear of it.

The Safety of Nuclear Energy

We will start with the last part as we think this is the most important one. To start, the biggest concern, that being the concern of them blowing up. This is not an actual concern since the technology and safety measures have evolved all the RBMK (reactors like the Chernobyl ones, which were not adopted by any country outside of the Soviet Union due to their inherent instability and unsafe operating characteristics. During the reduction of power, the RBMK reactor, which used graphite instead of water like American reactors, tended to increase power production sharply instead. This overheating would lead to an even further increase in power [1].) on the planet have been retrofitted [2] in such a way that makes them impossible to explode like the one from Chernobyl.

The explosion was caused by neglect. For example, the one in Fukushima, happened after multiple sources warned TEPCO (the ones who built the Station) that the station was unsafe [3], and an investigation was done after which revealed that it was necessary to have anticipated the tsunami that started the nuclear disaster [4]. As a matter of fact, it was not even the nuclear part of the station that caused the explosion since the earthquake that occurred on March 11, 2011, did not cause considerable damage to the Fukushima Daiichi and Daini nuclear plants.

The reactors at Daiichi automatically shut down in response to the earthquake, but all external power supply sources were lost, leading to a loss of cooling. The tsunami waves that followed the earthquake submerged and damaged the seawater pumps, diesel generators, and electrical switchgear, causing a station blackout and isolating the reactors from their ultimate heat sink and thus leading to an explosion [3]. Human failure was the reason for the reactor from Chernobyl as well since the accident was caused by the combination of human failures in the design of the reactor and online operations [5]. A different paper [6] has different thought “The Chernobyl accident consisted of a chain of events that were both extremely improbable and difficult to predict. It is not reasonable to

blame for the disaster on the operators.," but this is explained as such because "Chernobyl accident was initiated by a badly designed and unauthorized experiment, for which the persons behind it might be blamed.," meaning that both papers and many others like ([1, 7, 8] and many others), even if they do not agree on the exact reason for the explosion, they all agree human negligence was the biggest factor.

Radiation Scare

Now let us tackle the fear of radiation. People usually fear either the radiation because of waste or the result of an explosion, but since we showed, the explosion is caused by human negligence, a factor which over the years have less and less effect since increasingly since the introduction of more strenuous regulations such as

- The Convention on Nuclear Safety (1994)
- The Joint Convention on the Safety of Spent Fuel Management and the safety of Radioactive Waste Management (1997)
- The International Atomic Energy Agency (IAEA) Safety Standards
- The European Union's Nuclear Safety Directive (2009)
- The US Nuclear Regulatory Commission (NRC) regulations make explosions from human errorless and less likely.

And since human error is highly reduced, it leaves only errors from the reactors which are even more unlikely since the technology has seen many changes since 1986, a Layman comparison, would be the difference in today's standard for vehicle protection to the ones from the 1980s. Thus, making radioactive clouds like the ones after Chernobyl is highly unlikely since an explosion would have to appear first. This leaves the other scare of nuclear radiation and that is nuclear waste. There are 3[9]:

- Low Level (90-94%);
- Intermediate Level (5-7%);
- High Level (1-3%).

But, the only one we must worry about is the 1-3% since the rest of it is waste that decays fast and is not that dangerous [10, 11]. But, the remaining most dangerous ones represent only an amount of 400.000tons [12] (which fits inside of a 630x630m cube, or an American football field [11]), which is the total amount of nuclear waste ever produced since the first nuclear power plant, while something like industrial production waste amounts only in China to 75 Megatons (75 million tons) only in 2018 [13]. But there is still a need to store all this waste, so the most common way it is done today is to cool it down using water, then melt it with sand and glass and encase it in a very secure container (here is a video of a train crashing into one [14]), or just recycled [11].

Environmental Impact of Nuclear Energy

"Nuclear power is one of the few energy sources that does not produce carbon dioxide or other greenhouse gases that contribute to climate change. In fact, nuclear power plants produce virtually no air pollutants, making them a valuable source of clean energy. Compared with other types of energy sources, nuclear power has a relatively small environmental footprint, and its life cycle emissions are generally lower than those of fossil fuels and are comparable to or lower than other forms of renewable energy, such as wind and solar. Additionally, nuclear power plants have a low land use requirement, with a typical nuclear power plant occupying only a few square kilometers. Unlike fossil fuels, nuclear power does not produce air pollution, acid rain, or toxic waste. Overall, nuclear power has the potential to make a significant contribution to mitigating climate change and improving air quality, while also meeting the world's growing energy demands." [12]

In the following table, we have detailed a Comparison between the Pollution from Nuclear reactors and other types of Energy sources, according to this IPCC report.

Table 1

Comparison between the Pollution from Nuclear reactors and other types of Energy sources [12]

Energy Sources	Pollution Comparison	
	Median	Maximum
Coal	68.3x	8.2x
Gas	40.8x	5.9x
Biomass-Cofiring	61.6x	8.09x
Biomass-Dedicated	19.1x	3.81x
Geothermal	3.16x	0.71x
Hydropower	2x	20x
Solar	4x	1.63x
Wind	0.91x	0.5x

Only Wind energy out of all available options can be considered slightly better, and all other options are producing more waste than nuclear energy. Furthermore, when compared to Solar or Wind energy sources, Reactors require less space to build. Therefore, the damage to the environment via all kinds of terra-forming can be considered less than them too.

Alternative Fuels for Nuclear Energy

For decades, uranium has been the primary fuel source for nuclear reactors. However, the growing concerns over nuclear waste and the environmental impact of uranium mining have led scientists and researchers to explore alternative fuels for nuclear energy [16]. One promising alternative is thorium, a naturally occurring radioactive element that is abundant in the Earth's crust [17].

Unlike uranium, thorium does not produce weapons-grade material and has a lower risk of nuclear proliferation [18]. Also, thorium reactors can be safer and more efficient than traditional uranium reactors. One of the main advantages of thorium over uranium is its abundance [17]. While uranium reserves are limited and concentrated in a few countries, thorium is four times more abundant than uranium and is widely distributed around the globe.

Another advantage of thorium is its lower risk of nuclear proliferation [18]. Unlike uranium, thorium cannot be used to produce weapons-grade material, making it less attractive for weapons production. This means that countries with nuclear energy programs could potentially use thorium reactors without the same level of international scrutiny and regulation as uranium reactors.

Thorium reactors also can be safer and more efficient than traditional uranium reactors. Thorium is a more stable fuel source than uranium, which means that it produces less radioactive waste and is less prone to nuclear accidents [16]. Additionally, thorium reactors can be designed to operate at higher temperatures, which would make them more efficient at producing electricity.

Despite the potential benefits of thorium, there are still some technical and economic challenges that need to be overcome before it can become a viable alternative to uranium [2]. One of the main challenges is that thorium reactors are still in the experimental stage, and there is not yet a proven commercial design. This means that significant research and development is needed before thorium reactors can be deployed on a large scale.

There are also economic challenges to overcome, as the infrastructure for thorium fuel production and recycling would need to be developed. Additionally, there are concerns about the cost of transitioning from uranium to thorium, as existing nuclear reactors would need to be modified or replaced.

Despite these challenges, there is growing interest in thorium as a potential alternative to uranium. In recent years, several countries, including India and China, have invested in thorium research and development programs [3]. In the United States, the Department of Energy has also funded research into thorium fuel and reactors [2].

Conclusions

In conclusion, while uranium has been the primary fuel source for nuclear reactors for decades, the growing concerns over nuclear waste and the environmental impact of uranium mining have led scientists and researchers to explore alternative fuels for nuclear energy [2]. One promising alternative is thorium, a naturally occurring radioactive element that is abundant in the Earth's crust [3]. Thorium has several advantages over uranium, including its abundance, lower risk of nuclear proliferation, and potential for safer and more efficient reactors. While there are still technical and economic challenges to overcome, the growing interest in thorium research and development suggests that it could become a viable alternative to uranium in the future.

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