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MORALITY BEFORE KNOWLEDGE

# Climate change: Energy electricity in Indonesia

**Rafi Fikri Setyoadi**[1,*]
[1] *Environmental Engineering, Faculty, of Engineering President University, Bekasi 17550, Indonesia.*
*Correspondence: rafifikri123@gmail.com

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## ABSTRACT

**Background:** Electrical energy is currently the most widely used and essential energy form globally. It is generated due to a charge difference across two points in a conductor, typically produced by power plants. Among these, Nuclear Power Plants (NPPs) serve as thermal power plants that utilize one or more nuclear reactors with uranium as the heat source. As the world faces the challenge of air pollution and climate change, there is a critical need to transition from fossil fuels to clean energy **Methods:** This study uses a comparative approach to examine the emissions and health impact differences between nuclear energy and fossil-based power sources. It incorporates literature review data on GHG emissions per kWh and air pollutant release from different energy sources, analyzing nuclear power's emission footprint across its lifecycle (construction, fuel cycle, decommissioning). **Findings:** Nuclear energy emits only 12g $CO_2$ equivalent per kWh, significantly lower than pulverized coal (820g) and natural gas (490g). It also releases no toxic air pollutants during operation, thus reducing respiratory disease risks. Additionally, radiation release from NPPs is extremely low, debunking common misconceptions. **Conclusion:** Nuclear energy is a clean, safe, and effective alternative to fossil fuels. It has the potential to significantly reduce air pollution-related deaths and mitigate climate change through reduced $CO_2$ emissions. With current technology and layered safety designs, nuclear energy is a viable solution for future sustainable energy development. **Novelty/Originality of This Study:** The study uniquely emphasizes the comparative environmental and health advantages of nuclear power over fossil fuels, highlighting quantified emission data and dispelling misconceptions about radiation from NPPs. It also reinforces nuclear energy's role in a future clean energy mix, supported by life-cycle analysis and health impact perspectives.

**KEYWORDS**: electrical energy; emissions; nuclearr.

## 1. Introduction

Indonesia has serious challenges to meet its increasing energy needs but must remain environmentally friendly and sustainable. Indonesia is a maritime/archipelagic country, a unique country in the world and there is no country like Indonesia, so Indonesia has a different electricity supply profile than continental countries. It is impossible for Indonesia to import electricity from other countries, therefore, Indonesia must be independent in processing energy, especially electrical energy.

Electrical energy is the energy that is currently most widely used and considered important by the world's population. This energy arises because of the difference in charge between the two points of the conductor. Electrical energy generated by a power plant. Energy stored in electric currents in units of amperes (A) and electric voltages in units of Volts (V) provided that the need for electric power consumption in units of Watts (W) is used to drive motors, lights, heat, cool or reactivate mechanical equipment. to produce other

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forms of energy. This energy can be obtained from changes in various energy sources such as water, wind, heat, light, and fossil fuels (chemicals).

Regulation of the Minister of Energy and Mineral Resources Number 45 of 2017 concerning Utilization of Natural Gas for Power Generation aims to regulate the technical side and price of natural gas for power plants and ensure the availability of natural gas supply at fair and competitive prices, both for pipeline gas and LNG . This aims to keep the selling price of electricity competitive by paying attention to the upstream side. With a reasonable gas price on the upstream side, a competitive selling price for electricity will be obtained. In addition, this Ministerial Regulation covers the development of power plants at the mouth of the well (wellhead). Regarding the availability of natural gas supply for power plants, the Government has also issued Decree of the Minister of Energy and Mineral Resources Number 1750 K/20/MEM/2017 concerning Determination of Allocation and Utilization of Natural Gas for the Provision of Electricity by PT PLN (Persero) as amended by Decree of the Minister of Energy and Mineral Resources 1790 K/20/MEM/2018. This regulation aims to guarantee the availability of natural gas supply for power generation and specifically regulates the priority of allocation and utilization of natural gas for electricity supply as an exception to the Regulation of the Minister of Energy and Mineral Resources Number 06 of 2016 concerning Provisions and Procedures for Determining Allocation and Utilization and Natural Gas Prices. Regulation of the Minister of Energy and Mineral Resources Number 50 of 2017 concerning Utilization of Renewable Energy Sources for the Provision of Electricity as amended by Regulation of the Minister of Energy and Mineral Resources Number 53 of 2018 regulates the mechanism and purchase price of electricity from renewable energy plants. The types of generators regulated are Solar Power Plant/*Pembangkit Listrik Tenaga Surya* (PLTS) photovoltaic, Wind Power Plant/*Pembangkit Listrik Tenaga Bayu* (PLTB), Hydroelectric Power Plant/*Pembangkit Listrik Tenaga Air* (PLTA), Biomass Power Plant/*Pembangkit Listrik Tenaga Biomassa* (PLTBm), Biogas Power Plant/*Pembangkit Listrik Tenaga Biogas* (PLTBg), Waste to Energy Power Plant/*Pembangkit Listrik Tenaga Sampah* (PLTSa), Geothermal power plant/*Pembangkit Listrik Tenaga Panas Bumi* (PLTP) and marine hydropower.

On the other hand, the growth in electricity supply by PLN until 2015 was 272,952 GWh with a sales target of 257,401 GWh. With this increased growth, the use of fossil energy is still the prima donna. This can be seen from the national energy policy (energy mix) until 2025 which places a very large dependence on fossil energy, namely 85%. The composition of energy use (energy mix) nationally is oil 26.2%, coal 32.7% natural gas 30.6%, geothermal 3.8% and the rest is alternative energy/new renewable energy 4.4% ((Micro Hydro Power Plant/*Pembangkit Listrik Tenaga Mikrohidro*) PLTMH 0.216%, PLTS 0.02%, PLT Wind 0.028%, Biomass 0.766%, Biofuel 1.335%, Nuclear 1.993%). Energy mix based on the year's PLN Company Work Plan & Budget/*Rencana Kerja & Anggaran Perusahaan* (RKAP).

Nuclear Power Plant (PLTN) is a thermal power plant that uses one or several nuclear reactors as its heat source. The working principle of a nuclear power plant is almost the same as a steam power plant, using high pressure steam to turn a turbine. This turbine rotation is converted into electrical energy. The difference is the heat source used to produce heat. A nuclear power plant uses Uranium as its heat source. Maintaining the continuity of life on earth and preventing death from air pollution requires conversion from fossil energy to clean energy. Nuclear is a viable alternative to clean energy as a substitute for fossil energy. Nuclear energy has advantages over fossil energy, including cheap, clean, reliable and sustainable. The PLTN was chosen because it is efficient, the application of increasingly advanced technology and can create a more comfortable environment for the community, said Karunia. Furthermore, Karunia said, apart from being environmentally friendly energy, PLTN is also far better than energy such as water or the sun. The current NPP technology has been tested and has a layered design. So that for the Safety, Security and Safeguards factor a PLTN has met the requirements that have been set. It takes a good understanding of nuclear from the public.

## 2. Methods

The energy that is converted into electrical energy through the rotating turbine of the dynamo is capable of producing an electric field. For light, the electrical energy is obtained by a photovoltaic reaction on the surface, causing a difference that is responsible for generating electricity. The use of electrical energy for daily needs, such as tvs, air conditioners, lights, refrigerators, washing machines, microwaves and various other electrical equipment is in fact directly proportional to the production of gas emissions. Because of the source of electrical energy that we use. Mostly, the source of electrical energy still comes from burning fossil materials in power plants. So that the combustion that is carried out is by combining oxygen which produces co2, the cause of air pollution which results in global warming.

The increasing concentration of carbon dioxide gas ($CO_2$) and other gases in the earth's atmosphere makes the earth's atmosphere retain more heat from the sun, so that the earth's atmosphere or the ozone layer on our earth is thinning. This causes an increase in the earth's temperature which results in global warming. Excessive use of electricity will trigger global warming because the electricity used is the result of burning coal which will produce carbon dioxide which will be trapped in the atmosphere and cause an increase in the average temperature of the atmosphere, sea and land earth.

In the case of the Cost of Education Administration/*Biaya Penyelenggaraan Pendidikan* (BPP) & Basic Electricity Tariff/*Tarif Dasar Listrik* (TDL) problem, when producing it must follow the market price, while TDL is under the authority/decision of the President through. The most burdensome/burdening burden to PLN is when the power plant uses fuel as primary energy. PLN is treated as an industry, to buy fuel it must follow market prices, and the benchmark is the fluctuating world fuel market prices. If the global fuel market price exceeds $100 per barrel, then the equivalent price per liter surpasses IDR 9,000. In this situation, PLN purchases fuel at IDR 9,000 per liter, resulting in a basic production cost (BPP) of over IDR 3,000 per kilowatt-hour (kWh) for power plants that rely on fuel oil. The calculation of the BPP per kWh takes into account several components. First, the fuel requirement is such that 1 liter of fuel generates approximately 3 kWh, which implies that the fuel cost alone for producing 1 kWh is around IDR 3,000. In addition to this, there are costs associated with the transportation and handling of fuel from the Pertamina depot to PLN's power plants. Furthermore, the BPP must also consider development or investment costs, which include the establishment and maintenance of generation, transmission, distribution infrastructure, and supporting facilities. Finally, other operational expenses contribute to the overall cost structure, making fuel-based electricity generation relatively expensive under such market conditions.

So with the BPP which consists of several of the above elements, if the accumulated cost of BPP per kwh can reach almost IDR 4,000.-. We know that PLN's power plants consist of various types and use primary energy, including: water, gas, coal, fuel, and geothermal. If the average BPP is made for the various types of power plants owned by PLN, currently the average BPP is ± IDR 1,200/kwh. Whereas currently the TDL is ± IDR 700, -/kwh. After all, this condition will result in PLN continuing to experience a deficit. When considered as a business, it is an ironic business. So that electricity can still operate and serve the PLN community, the government (state) is obliged to provide subsidies (subsidies are given to the community, not PLN). In 2011, the government (state) provided subsidies for the supply of electricity amounting to IDR 65,000,000,000,000.- (sixty-five trillion rupiah). Without subsidies, it is certain that electricity will experience rotating blackouts.

Related to the issue of climate change, nuclear does not release GHG emissions when it operates. GHG emissions are released only in indirect processes, namely construction, fuel cycle and decommissioning. Thus, the specific emissions of nuclear energy are very low, only 12g $CO_2$ equivalent per kWh. As a comparison, pulverised coal has a specific emission of 820 g $CO_2$ equivalent per kWh and natural gas of 490g $CO_2$ equivalent per kWh. Nuclear energy also does not release toxic pollutants into the air when it operates. Thus, nuclear

does not contribute to causing respiratory diseases. Some people think that radiation from a nuclear power plant is potentially dangerous, but in fact the release of radiation from a nuclear power plant into the environment is very low. Therefore, the use of nuclear energy can prevent deaths due to air pollution and avoid the release of large amounts of $CO_2$ into the atmosphere. This is historically proven and has the potential to apply in future scenarios.

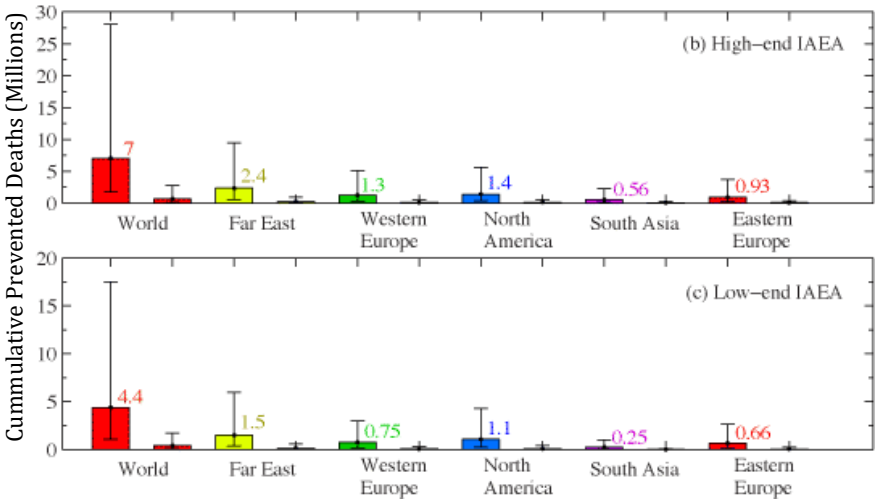


Fig. 1. Projected deaths that can be prevented in the future by using nuclear energy. The left graph shows the all-coal mix and the right graph shows the all-natural gas mix; (above) IAEA high-end scenario, (below) IAEA low-end scenario
(Kharecha & Hansen, 2013)

Using a similar scenario and mix, it is also projected how much potential GHG can be prevented from being released into the atmosphere. In an all-coal mix, 150 Giga Tonnes of CO2 equivalent could be prevented from being released in a low-end scenario. Meanwhile, in the high-end scenario, the release of 240 Giga Tonnes of $CO_2$ equivalent can be prevented. The all-gas mix shows lower figures, namely 82 Giga Tonnes of $CO_2$ equivalent in the low-end scenario and 130 Giga Tonnes of $CO_2$ equivalent in the high-end scenario. However, this has not really considered the potential for methane leakage in natural gas drilling. Because again, a 4% methane leak makes natural gas as bad as coal.

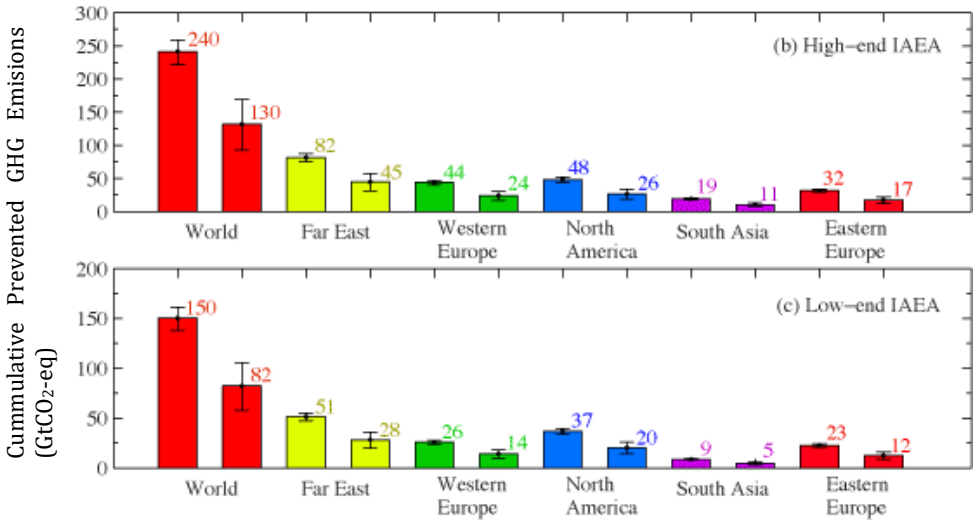


Fig. 2. Projection of GHG emissions that can be prevented in the future by using nuclear energy. The left graph shows the all-coal mix and the right graph shows the all-natural gas mix; (above) IAEA high-end scenario, (below) IAEA low-end scenario
(Kharecha & Hansen, 2013)

If not for various political obstacles, the growth of nuclear energy in 2015 alone could have replaced 100% of coal burning and 76% of natural gas burning, as revealed by Lang (2017) in his analysis. More deaths could have been avoided, namely 9.5 million people, and more GHG could have been prevented from being released into the atmosphere, namely 174 million tonnes of $CO_2$ equivalent.

In order for global warming to be reduced to less than 2°C (less than 1.5°C, according to James Hansen), the need for clean energy is indeed very crucial. Particularly nuclear, which so far has been successful in preventing large amounts of GHG from being released into the atmosphere. With power plant characteristics similar to coal (minus GHG emissions), nuclear is able to substitute fossil energy without much problem. The problem is only political obstacles and still rampant misleading myths about nuclear. All of that must be straightened out, so that the benefits of nuclear can be fully felt.

## 3. Results and Discussion

The first challenge is the supply of electrical energy which is increasing in line with increasing population and welfare. The second challenge is how to realize this energy demand by providing reliable, environmentally friendly and sustainable energy in line with Indonesia's commitment to achieving sustainable development goals (SDGs) from the United Nations (UN) in 2030 and commitment to the Paris Agreement or Conference of Parties (COP). 21). The third challenge is how Indonesia has unique energy solutions in accordance with geographical conditions, the availability of natural resources (SDA) and human resource capabilities (HR) so that Indonesia is equal to other countries, leading in energy.

The definition of sustainable environmentally friendly energy and its implementation needs to be reviewed to determine the energy transition to replace fossil energy in Indonesia. Things that need to be emphasized regarding environmentally friendly energy are as follows.

Environmentally friendly energy must produce low Greenhouse Gas (GHG) emissions throughout its entire lifecycle, including emissions generated during the mining process, transportation, operational phase, and the total operational cycle. In addition, it should require only a minimal land footprint in order to reduce the negative impacts of land use changes, which is especially crucial in a country like Indonesia, where land availability is limited due to its archipelagic nature. Environmentally friendly energy should also be economically viable for both consumers and industries, with production costs that are affordable even without government subsidies, and must ensure a reliable, long-term supply of raw materials and fuel. Furthermore, it must possess reliability and sustainability as essential characteristics. As electrical energy remains the most widely used and important form of energy across the globe, originating from the difference in electric charge between two points in a conductor and delivered through power plants, it plays a critical role, particularly in areas with high population density. To be truly sustainable, environmentally friendly energy must also preserve ecological balance by ensuring the safety of the surrounding environment, flora, and fauna throughout its operation. This includes preventing negative impacts such as changes in temperature, air and noise pollution, and disruptions to water reserves. Moreover, environmentally friendly energy systems must implement standardized procedures for waste management, ensuring proper handling, treatment, and supervision to avoid long-term environmental harm.

Apart from the five requirements for environmentally friendly energy above, environmentally friendly energy must also be sustainable, both in terms of natural resources in the form of raw materials and fuel, as well as from an economic point of view. Environmentally friendly energy provides quality electricity supply at a lower price compared to the Volt (V) unit provided that the need for electrical power consumption is in Watts (W) units to drive motors, lighting, heat, cool or to reactivate a mechanical equipment

to produce shapes. This energy can be obtained from changes in various energy sources such as water, wind, heat, light, and fossil fuels (chemicals).

The composition of PLN customers is dominated by low voltage (TR) customers whose contribution reaches 61 percent, while TM customers account for 32 percent, and TT customers only account for 7 percent. This causes Indonesia's per capita energy consumption to be relatively low, namely around 972 kWh per capita per year in 2019, so that the achievement of losses is higher compared to developed countries, which have higher electricity consumption per capita. In the Java-Bali electricity system, said Haryanto, there is still a scenario of continuing power transfer in the transmission system from east to west because demand for electricity in the eastern region is still low, while supply is excess. Meanwhile, in the western part of the electricity supply is still lacking. To reduce losses, ideally inter-regional power transfers should be minimized or even absent and power transfers are only needed when there is a supply deficit in the short term. He said that reducing losses is not an easy thing and requires a sizable investment. However, PLN is committed to reducing network losses according to the government's mandate. One of the efforts is to improve the structure of the transmission network in Java-Bali by building more power plants in the western part. As for 2020, PLN recorded that the national network losses reached 9.19 percent of the target set at 9.20 percent, while the Java-Madura-Bali regional network losses were 8.4 percent.

PLTN was chosen because it is efficient, the application of increasingly advanced technology and can create a more comfortable environment for the community. PLTN in addition to environmentally friendly energy, is also much better when compared to energy such as water or the sun. but no matter how good it is, there are still doubts from a number of people regarding plans to build nuclear power plants in Indonesia, the Head of BAPETEN emphasized, these worries really don't need to happen. Because the supervisory system that is currently implemented by BAPETEN always involves the IAEA, and continues to be carried out according to current technological developments, said the Head of BAPETEN. The head of BAPETEN added that the Chernobyl incident was inseparable from the abuse of utilization, at that time the PLTN was used as an experiment. It is this misuse that later becomes a problem and influences the public's negative perception of nuclear power so far.

Meanwhile, Energy Watch Executive Director Mamit Setiawan believes that nuclear could be a consideration for Indonesia in the future. Along with nuclear technology that is getting safer and more efficient in investment, nuclear is no longer the last choice for Indonesia. In addition, with the reserves of uranium and thorium that Indonesia has, nuclear can be an alternative source of energy in the future. "Not to mention that nuclear is the cleanest energy source when compared to other energies, especially EBT. This is due to NRE, such as solar and wind requiring additional energy as a peaker, considering they are intermittent. So it requires fossil energy, such as gas or coal as a back up. However, nuclear does not require that," said the Executive Director of Energy Watch

However, in the use of nuclear itself has an estimated effect. Nuclear reactors, because there is a very high concentration of energy in the fuel, require very little amount of fuel and produce only a small amount of final waste. But both the fuel and the waste require processing and transportation. The possibility of accidents during the transportation of radioactive waste is a public concern, because there are still unresolved long-term storage safety issues of radioactive waste. Because uranium occurs in low concentrations in the earth's crust, its extraction needs to be labor intensive and the risks of injury and illness (especially lung disease and cancer) for workers mining and processing the mineral are very high.?

Accidents in nuclear reactors, although rare, pose a serious potential risk to the health of workers at the nuclear power plant and its surroundings, perhaps even to residents who live far away. Nuclear optimists anticipate new improvements for risk reduction in reactor technology (including passive self-monitoring designs, safety mechanisms), safe underground disposal.

## 4. Conclusions

Even though in Indonesia the electricity available for use is not evenly distributed, many have experienced climate change. Not only climate change is experiencing changes, there are also costs that we will incur, as for the reason why the use of electricity is not evenly distributed, namely network losses is a parameter of the efficiency of the electric power network which will affect the cost of supply (BPP) as well as the need for electricity subsidies. The higher the network losses, the more inefficient the supply of electricity will be. The large per capita energy consumption in a country is influenced by the composition of large power industry and business customers, namely sales of the high voltage (TT) and medium voltage (TM) customer segments

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The authors declare no conflict of interest.

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## Biographies of Author

**Rafi Fikri Setyoadi,** Environmental Engineering, Faculty, of Engineering President University, Bekasi 17550, Indonesia.

- Email: rafifikri123@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A