# Study of Carbon Emissions in the Use of Fossil and Renewable Energy to Respond to the Urgency of a Sustainable Energy Transition in Indonesia's Group of Twenty (G20) Presidency: A Short Communication

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**Abstract.** The energy industry is responsible for about 90% of carbon dioxide ($CO_2$) emissions on a worldwide scale, making it the primary contributor to climate change. The Group of Twenty (G20) members are making substantial endeavors to accomplish a sustainable energy transition primarily due to the imperative of addressing climate change. The observable consequences of global climate change on many aspects of life include the disappearance of ice in the Arctic, the increase in sea levels, and the persistence of extended periods of drought. The use of renewable energy sources in power production systems has been shown to significantly mitigate carbon emissions during their whole life cycle. The most significant decrease in carbon emissions during the whole life cycle, transitioning from coal to wind, amounts to 87.32% (≈851.6 g $CO_2$ per kWh). The Indonesian government expresses optimism over its ability to achieve a state of net-zero emissions by the year 2060, accompanied by a renewable energy mix of 23% by 2025. In conclusion, Indonesia is poised to make a significant contribution towards the shift from fossil-based energy sources to renewable alternatives, ultimately striving to attain sustained net zero emissions.

## 1 Introduction

Indonesia will assume the chairmanship of the Group of Twenty (G20) for a duration of one year, commencing on 1 December 2021 and concluding with the G20 Summit in November 2022. The 17th G20 summit is scheduled to take place in Bali on November 15-16, 2022. The summit signifies the completion of the comprehensive procedures and efforts undertaken by the whole G20 process, including Working Groups, Engagement Groups, and Ministerial Meetings, over Indonesia's tenure as chairman [1, 2].

The commitment of the G20 member states to resolving the problem of global climate change is demonstrated by the "sustainable energy transition" being one of the summit's top priorities [2]. Climate change is the primary impetus for the energy transition. Nearly 90% of global carbon dioxide ($CO_2$) emissions are produced by the energy sector, rendering it the leading cause of climate change. In addition, the Indonesian government aims to achieve a net-zero carbon footprint by 2060 and a 23% new and renewable energy mix by 2025 [3, 4].

The G20 is a multilateral strategic platform that connects countries with the world's largest economies. The G20 plays a crucial role in determining the future of global economic expansion. This is due to G20 members represent over 60% of the world's population, 75% of international trade, and 80% of the global economy. The G20 meetings, which began in 1999 as a gathering of Finance Ministers and Central Bank Governors, have expanded to include annual summits attended by the respective Heads of State and Heads of Government [2].

Net zero emissions or zero carbon emissions refers to a situation in which the quantity of carbon emitted into the atmosphere is not greater than what the earth can absorb [5, 6]. The concept of net zero emissions does not refer to the elimination of human produced emissions. Obviously, humanity and the world cannot if they do not emit greenhouse gases. For example, humans exhale carbon dioxide ($CO_2$) when they breathe. When the number of humans is multiplied by 7.8 billion, carbon emissions from human respiration account for 5.8% of the total volume of annual carbon emissions. Carbon neutral, also known as carbon negative, refers to the absence of carbon emissions. This means that

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human-produced emissions can be completely absorbed by the earth's ecosystem, so that no greenhouse gases are emitted into the atmosphere. Naturally, vegetation, water, and soil absorb emissions [5, 7].

The use of fossil energy within industrial sectors results in a surplus of carbon emissions being discharged into the atmosphere, surpassing the ability of trees, oceans, and soil to absorb such emissions. The aforementioned phenomenon leads to the occurrence of global warming and climate change [8, 9]. As a result, the present composition of G20 member nations includes Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, United Kingdom, and the United States. Both the United States and the European Union have shown their commitment to mitigating carbon emissions within the industrial sector by prioritizing a sustainable energy transition. One of the objectives to be attained via the strategic concern of sustainable energy transition is the attainment of net zero emissions for member nations of the G20. The member nations of the G20 together represent around 75% of the total global energy demand. Hence, it can be argued that the G20 nations have a significant responsibility and occupy a pivotal position in promoting the use of sustainable energy sources [4].

The aims of this review article are to comprehend the process of global warming and its implications for global climate change, examine the sustainable energy transition as a means to mitigate carbon emissions throughout the life cycle, and analyze the Indonesian government's strategy to attain net zero emissions by the year 2060.

## 2 Writing method

The stages of article writing carried out: The author formulates a problem or setting a theme that will be discussed in the article on sustainable energy transition. The author develops a theoretical framework for research that has been carried outs on the carbon emissions in the use of fossil and renewable energy. The writing process uses references to proceedings and international journal articles. At this stage, the author describes the carbon emissions in the use of fossil and renewable energy to respond to the urgency of a sustainable energy transition in Indonesia's G20 presidency starting from the background of the problem, the purpose of writing the article, the results and discussion, then the conclusions.

## 3 Results and Discussion

### 3.1 The Global Warming Process and Its Influence on Global Climate Change

The industrial activities and facilities that produce electricity, namely methanol factories, urea factories, and steam energy plants, continue to use coal as a fuel that can generate carbon dioxide ($CO_2$), sulfur dioxide ($SO_2$), and nitrogen dioxide ($NO_2$) [10-14]. Transportation in the industry, such as vehicles, likewise is contributing to rising emissions of $CO_2$ due to diesel is utilised [11, 15, 16]. Fig. 1 serves as an illustrative representation of $CO_2$ emissions from industrial processes, energy production, and transportation.

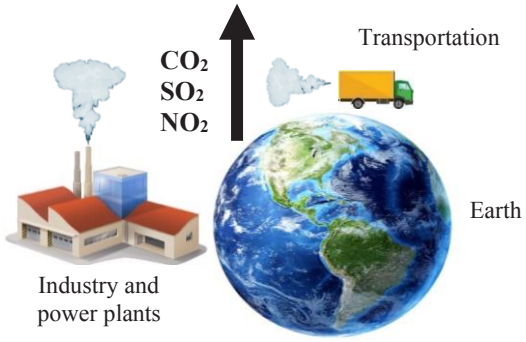


**Fig. 1.** $CO_2$ emissions from industrial processes, energy production, and transportation.

Emissions of carbon dioxide are going to be released into the ambient environment eventually reaching the strata of the atmosphere of the earth. The carbon dioxide ($CO_2$) atmosphere is going to reflect the sun's infrared radiation back to Earth. Reflected infrared radiation from the sun will increase the earth's temperature and eventually lead to global warming [17, 18]. Fig. 2 is an illustration of the process of global warming.

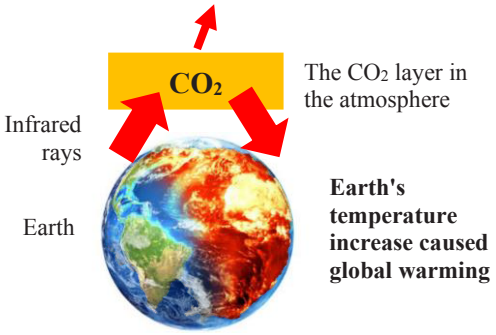


**Fig. 2.** The process of global warming.

People's actions are believed to have generated between 0.8 and 1.2 degrees Celsius of temperature rise over levels prior to industrialization, with a range of 1.0 to 1.2 degrees Celsius. If global warming continues to increase at its present rate, it will likely reach 1.5 degrees Celsius between 2030 and 2052 [19, 20]. Fig. 3 shown recorded variations in global temperature and simulated reactions to emissions from humans and forced routes [5].

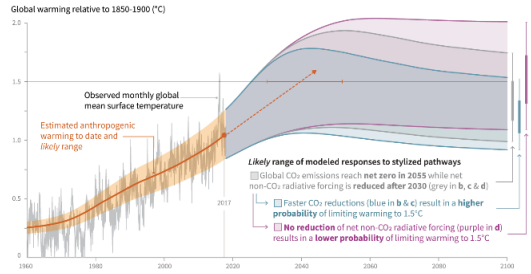


**Fig. 3.** Recorded variations in global temperature and simulated reactions to emissions from humans and forced routes [5].

Global climate change is one of the effects of global warming that influences the temperature of the environment. The increase in temperature may not seem excessive, but in countries like Indonesia, it can have a significant effect. Humans are susceptible to a variety of climate-related dangers, including Arctic ice thawing, rising sea levels, flooding, extended drought periods, strong winds, landslides, forest fires, and health issues [21, 22]. Ecosystem climate change and human health is the name of this event [23]. Fig. 4 depicts the phenomenon of the impact of global climate change.

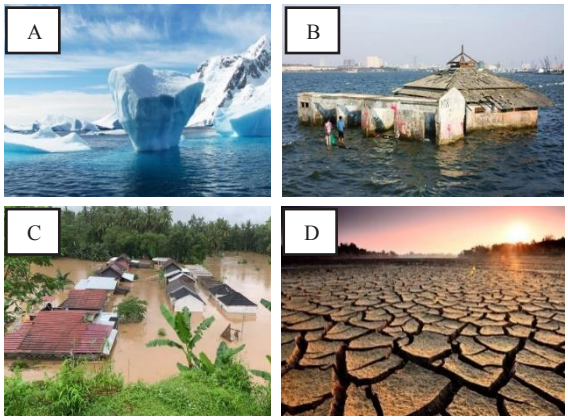


**Fig. 4.** A) Melting of ice in the Arctic, B) Rising sea levels, C) Floods, D) Long dry spells [24-27].

### 3.2 Sustainable Energy Transition to Reduce Carbon Emissions

The transition to a sustainable energy source was selected as one of the three primary problems of the G20 presidency in order to reduce $CO_2$ emissions in the industrial and power generation sectors. Diesel fuel is still utilised for truck conveyance in the industry. The impact of global warming on the production and use of diesel is greater than that of biodiesel (Table 1) [10]. The use of biodiesel as a fuel can reduce global warming by 1,300 kg $CO_2$ equivalent when compared to diesel (Table 2). Table 1 shown global warming potential of palm biodiesel compared to diesel.

**Table 1.** Global warming potential of palm biodiesel compared to diesel (per 1,000 L of biodiesel).

| Environmental impact | Unit | Scope | Diesel | Biodiesel | Reference |
|---|---|---|---|---|---|
| Global warming | kg $CO_2$ eq | Production + Usage | 2,798 | 1,498 | [10] |

Energy production in Indonesia is one of the industries that consumes the most fossil fuels, specifically coal. Coal is the harshest form of energy compared to oil and natural gas. Coal has the highest emissions, at 975.3 g-$CO_2$/kWh, followed by oil (742.1 g-$CO_2$/kWh) and natural gas (607.6 g-$CO_2$/kWh). Wind (123.7 g-$CO_2$/kWh), solar photovoltaic cells (250 g-$CO_2$/kWh), biomass (178 g-$CO_2$/kWh), solar thermal energy (202 g-$CO_2$/kWh), and hydro (237 g-$CO_2$/kWh) have a carbon emission that is significantly lower than coal, oil, and natural gas [28]. Table 2 presented comparison of emissions (g-$CO_2$/kwh) of conventional power plants with renewable power generation sources.

**Table 2.** Comparison of emissions (g-$CO_2$/kwh) of conventional power plants with renewable power generation sources.

| Energy sources | Unit | Scope | Emissions | Reference |
|---|---|---|---|---|
| Conventional system | | | | [28] |
| Coal | g $CO_2$ per kWh | Usage | 975.3 | |
| Crude oil | g $CO_2$ per kWh | Usage | 742.1 | |
| Natural gas | g $CO_2$ per kWh | Usage | 607.6 | |
| Renewable system | | | | |
| Wind | g $CO_2$ per kWh | Usage | 123.7 | |
| Photovoltaic solar cells | g $CO_2$ per kWh | Usage | 250 | |
| Biomass | g $CO_2$ per kWh | Usage | 178 | |
| Solar thermal energy | g $CO_2$ per kWh | Usage | 202 | |
| Hydro | g $CO_2$ per kWh | Usage | 237 | |

Transitioning from fossil energy to renewable energy in power generation systems can significantly reduce carbon emissions over the system's life cycle. The greatest reduction in carbon emissions over the life cycle, from coal to wind, is 87.32%. The percentage of reduction in the life cycle of the fuel with the lowest carbon emission, diesel to biodiesel, was 46.46%. The transition from coal to hydro, solar thermal energy, biomass, solar photovoltaic cells, and wind results in a decrease of 74 to 87% in the carbon life cycle. The transition from Petroleum to hydro, solar thermal energy, biomass, solar photovoltaic cells, and wind reduces the carbon life cycle by 66 to 83 %. The transition from natural gas to hydro, solar thermal energy, biomass, solar photovoltaic cells, and wind reduces the carbon life cycle by 58 to 79%. Table 3 shown reducing carbon emissions in the transition from fossil energy to renewable energy in power plants.

**Table 3.** Reducing carbon emissions in the transition from fossil energy to renewable energy in power plants.

| Transition from fossil energy to renewable energy | Unit | Reduction of carbon emissions | Percentage (%) |
|---|---|---|---|
| Diesel to biodiesel | kg $CO_2$ eq | 1,300 | 46.46 |
| Coal to the wind | g $CO_2$ per kWh | 851.6 | 87.32 |
| Coal to photovoltaic solar cells | g $CO_2$ per kWh | 725.3 | 74.37 |
| Coal to biomass | g $CO_2$ per kWh | 797.3 | 81.75 |
| Coal to solar thermal energy | g $CO_2$ per kWh | 773.3 | 79.29 |
| Coal to hydro | g $CO_2$ per kWh | 738.3 | 75.70 |
| Petroleum to wind | g $CO_2$ per kWh | 618.4 | 83.33 |
| Petroleum to photovoltaic solar cells | g $CO_2$ per kWh | 492.1 | 66.31 |
| Petroleum to biomass | g $CO_2$ per kWh | 564.1 | 76.01 |
| Petroleum to solar thermal energy | g $CO_2$ per kWh | 540.1 | 72.78 |
| Petroleum to hydro | g $CO_2$ per kWh | 505.1 | 68.06 |
| Natural gas to wind | g $CO_2$ per kWh | 483.9 | 79.64 |
| Natural gas to photovoltaic solar cells | g $CO_2$ per kWh | 357.6 | 58.85 |
| Natural gas to biomass | g $CO_2$ per kWh | 429.6 | 70.70 |
| Natural gas to solar thermal energy | g $CO_2$ per kWh | 405.6 | 66.75 |
| Natural gas to hydro | g $CO_2$ per kWh | 370.6 | 60.99 |

### 3.3 Sustainable Energy Transition to Reduce Carbon Emissions

The Indonesian government implements five key principles to reduce carbon foot-print and attain net-zero emission conditions: 1) Increasing the use of new and renewable energy; 2) Reducing the use of fossil fuels; 3) Increasing the use of electric vehicles in the transportation sector; 4) Increasing the use of electricity in homes and businesses; 5) Using carbon capture and storage (CCS) [29]. Fig. 5 depicts the Indonesian government's plan to achieve net zero emissions by 2060 [3].

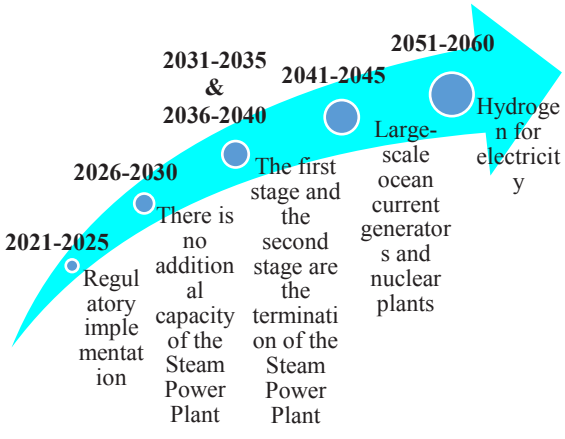


**Fig. 5.** The Indonesian government's road map towards net zero emissions in 2060 [3].

According to the Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR), the Indonesian government is developing a plan to achieve carbon neutrality by 2060 or sooner. This roadmap also incorporates demand-side initiatives required to support the energy transition, such as the use of electric appliances, Light Emitting Diode (LED) lighting, and city gas [3].

From 2021 to 2025, regulations will be issued and implemented, including laws regarding new and renewable energy, the early closure of coal-based power plants, the expansion of electric steam power plant co-firing, and the conversion of diesel to petrol and new and renewable energy. As an incentive for those who implement solar power plant roofs as a source of renewable energy, regulations pertaining to solar power plant roofs were issued so that their development could be accelerated. In addition, carbon tax policies (cap and tax) are developed to regulate the growth of greenhouse gas (GHG) emissions and alter the behaviour of economic activities so as to reduce GHG emissions. Beginning in April 2022, electric steam power plant will incur a limited carbon levy. The target proportion of renewable energy in 2025 is 23%, with solar photovoltaics as the dominant source [3].

From 2026 to 2030, there will be no additional electric steam power plant capacity because only contracted or under construction capacity will be available. Solar photovoltaic and electric vehicles will be developed extensively, with the goal of sup-porting the production of 2 million four-wheeled and 13 million two-wheeled vehicles respectively. Indonesia can meet its Nationally Determined Contribution (NDC) by reducing energy sector emissions by 314 million tonnes of $CO_2$ by 2030. The Indonesian government will begin phasing out electric steam power plant and reducing diesel consumption beginning in 2031. 57% of renewable energy will come from solar, hydro, and geothermal sources by 2035 [3]

In 2036-2040, the second phase of stopping the electric steam power plant will consist of subcritical, critical, and some supercritical measures. In the meantime, the new and renewable energy share will rise to 66%, dominated by solar, hydro, and bioenergy generators. Additionally, conventional two-wheeled vehicle sales have decreased. The Commercial Operation Date (COD) for the first large-scale ocean current generators and nuclear power facilities is between 2041 and 2045. Increased renewable energy usage to 93%, dominated by solar, hydroelectric, and bioenergy generators. Additionally, conventional four-wheeled vehicle sales will decline. Hydrogen for electricity will be developed on a significant scale between 2051 and 2060, which will be the final years of electric steam power plant use. Solar, hydro, and wind power dominate the development of renewable energy [3].

The transition from fossil energy to renewable energy can reduce carbon emissions, according to previous research [28, 30]. The urgency of a sustainable energy transition will yield positive outcomes, namely the decrease in greenhouse gases and the prevention of further global warming. Consequently, climate change impacts are able to be mitigated and avoided. The Indonesian government aims to achieve negative net emissions by 2060 and a 23% share of new and renewable energy by 2025. Maximising the use of renewable energy potential in Indonesia can achieve both of these goals [3, 4].

## 4 Conclusions

Global warming can be caused by carbon emissions from industrial activities, power generation, and transportation. Climate change is precipitated by global warming. The vanishing of glaciers in the Arctic, rising sea levels, floods, and extended droughts are true effects of global climate change on human life. The G20 member nations' response to the global climate change dilemma is a transition to sustainable energy. Transitioning from fossil energy to renewable energy in power generation systems has been shown to substantially reduce carbon emissions over their entire life cycle. The greatest reduction in carbon emissions over the life cycle, from coal to wind, is 87.32% (≈ 851.6 g $CO_2$ per kWh). The percentage of reduction in the life cycle of the fuel with the lowest carbon emission, diesel to biodiesel, was 46.46% (≈ 1,300 kg $CO_2$ eq). By maximising the use of renewable energy potential in Indonesia, the Indonesian government is optimistic that it is going to be possible to accomplish net-zero emissions by 2060 and its renewable energy mix goal of 23% by 2025. Indonesia is poised to make a significant contribution towards the shift from fossil-based energy sources to renewable alternatives, ultimately striving to attain sustained net zero emissions. In addition to producing $CO_2$ emissions, the combustion of fossil fuels also produces $SO_2$ and $NO_2$ emissions. $SO_2$ and $NO_2$ can cause acid precipitation. Acid rain can acidify freshwater, seawater, and terrestrial waters. Future scientific papers can concentrate on the effects of acidification of pure water, sea and land waters caused by industrial activities and fossil fuel-powered power plants.

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