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The Role of Clean Energy and Clean Transportation in Mitigating Climate Change: A Case Study of BTS Skytrain in Bangkok, Thailand

Cara Sasa Trirat, and Sasiphattra Siriwato*

School of Diplomacy and International Studies, Rangsit University, Pathum Thani 12000, Thailand

*Corresponding author, E-mail: sasiphattra.s@rsu.ac.th

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Abstract

This research paper examines the vital role of clean energy in mitigating climate change, with a focus on the BTS Skytrain system in Bangkok, Thailand. By analyzing this prominent clean transportation infrastructure, the study aims to identify both challenges and opportunities for integrating renewable energy sources into public transit networks. The objectives are to assess how the Bangkok Mass Transit System (BTS) contributes to climate change mitigation and to evaluate the effects of clean energy and transportation policies in the city. The researcher conducted interviews with six participants: three BTS personnel and three government officials specializing in energy, climate, and transportation. Findings reveal that the BTS is Thailand's first carbon-neutral rail service, significantly reducing greenhouse gas emissions through electric-powered operations. The BTS supports the government sustainability goals and promotes clean mobility, playing a crucial role in Thailand's transition to carbon neutrality by 2050. Moreover, the study highlights that clean energy and transportation policies in Bangkok are essential for combating climate change by reducing emissions and enhancing energy efficiency. These policies facilitate the adoption of renewable energy and electric vehicles, improving air quality and public health. Ultimately, Thailand's initiatives align with global efforts, demonstrating significant progress toward achieving carbon neutrality and fostering sustainable urban development.

Keywords: *Clean Energy; Climate Change; BTS Sky Train; Bangkok; Clean Energy Policies*

1. Introduction

Although the climate can change naturally over time, human activities like deforestation and the use of fossil fuels have sped up the rate of change over the past few decades (National Aeronautics and Space Administration, 2023c). This rapid change has brought about numerous issues. The first of these issues is rising temperatures. As you can see in Figure 1, the temperature was steady until it started to rise rapidly in the 1970s. The figure shows that the past decade has been the warmest on record (National Aeronautics and Space Administration, 2023b).

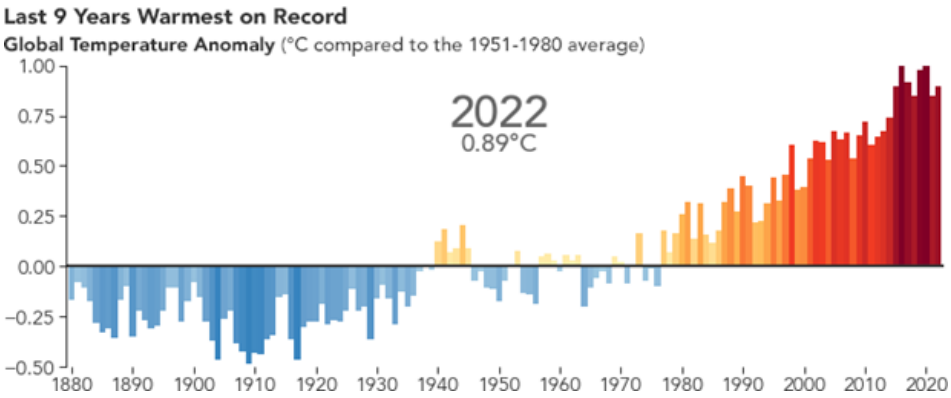

Figure 1 Global temperature anomaly through the year (National Aeronautics and Space Administration, 2023b)

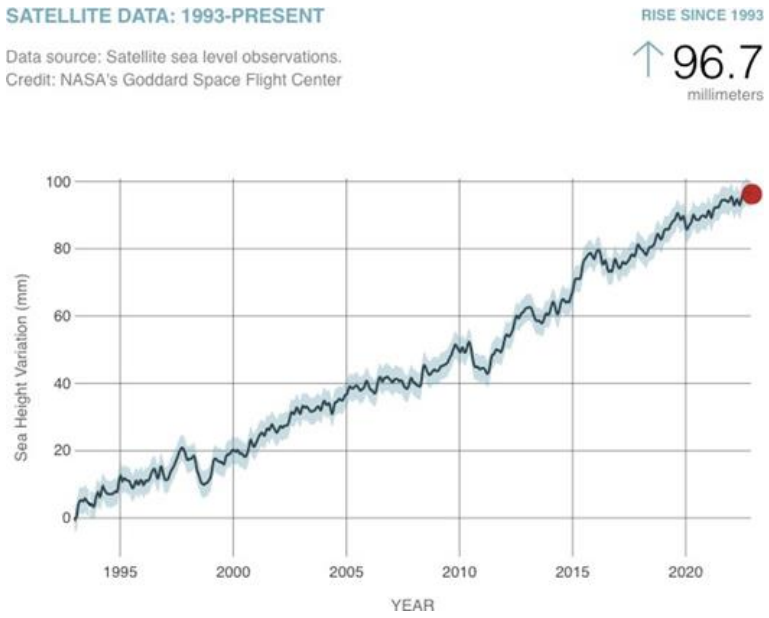

Figure 2 Rise in sea levels through the years (National Aeronautics and Space Administration, 2023a)

Another issue is that of the rise in sea levels. Figure 2 shows that the sea level has risen continuously since 1993; to this day, the sea has risen over 96 millimeters (National Aeronautics and Space Administration, 2023a). Other issues include extreme weather conditions, loss of biodiversity, health concerns, and acidification of the oceans (United Nations, 2023a; National Ocean Service, 2023). Apart from environmental and health issues, climate change is problematic for the economy and society as well (The World Bank, 2022). According to the "Global Risk Report 2024", environmental risk ranks highly across the charts and has held the 2nd place for two consecutive years. In addition, recent research predicts that by the early 2030s, long-term changes that may be irreversible will likely begin. Moreover, the current efforts to adapt to climate change cannot keep up with the rapid change (World Economic Forum, 2024). Therefore, it is significant that climate change and mitigation are further studied in hopes that arising knowledge will be able to present a solution to slow down climate change.

Clean energy helps reduce greenhouse gas emissions and air pollution, which are causes of climate change. According to Figure 3, there is a clear link between the amount of carbon emissions and renewable energy consumption. As renewable energy consumption started to rise around the 2010s, the number of carbon emissions gradually decreased; this shows that the use of renewable energy helps reduce carbon emissions (Ponce, & Khan, 2021). As clean energy is more widely used these days, the cost of technologies has dropped. However, there are still some challenges that need to be addressed. Firstly, developing infrastructure for clean energy can face challenges of limited resources and difficult areas of development (Toh, 2021). Another difficulty is the unpredictable weather patterns; while energy-storing technologies can solve this issue, they can be expensive and still need to be further researched (Energy Education, 2023; Roberts, 2019). In addition, legislation and laws can significantly help or impede the growth of renewable energy. Unpredictability in policies may deter investments in sustainable energy technologies (World Economic Forum, 2020). Lastly, even if clean energy emits fewer carbon emissions, its production and disposal still affect the environment (Union of Concerned Scientists, 2013).

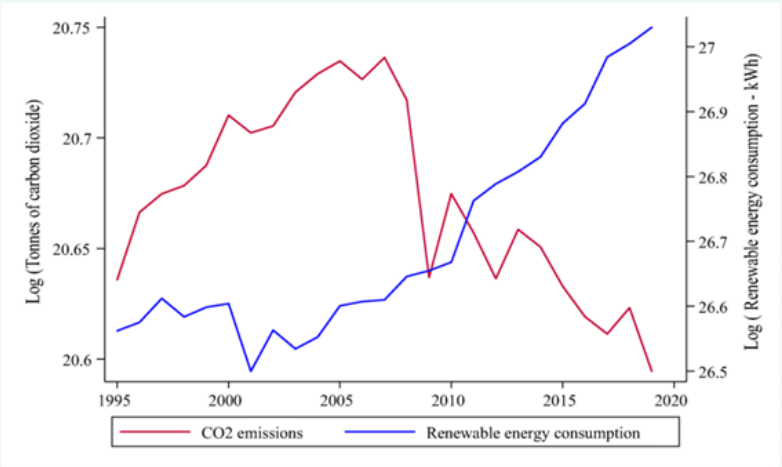

Figure 3 The link between renewable energy consumption and the number of carbon emissions (Ponce, & Khan, 2021)

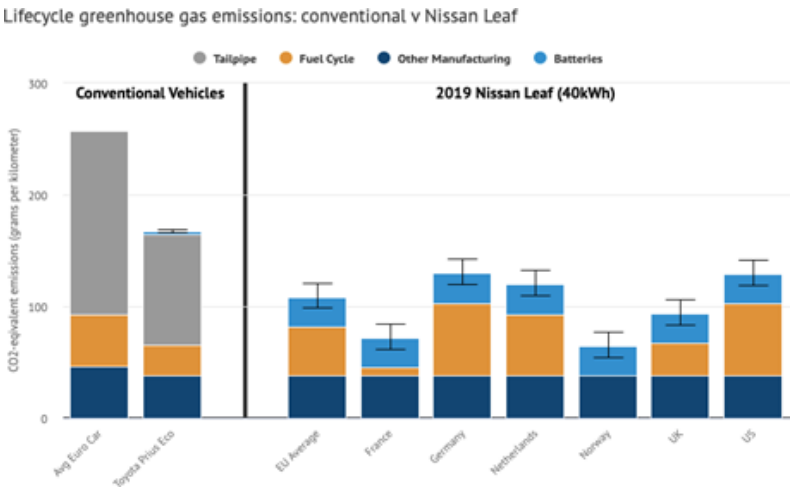

Figure 4 Comparison between conventional vehicles and clean energy vehicles' greenhouse gas emissions (Huasfather, 2019)

One of the main causes of climate change and air pollution is transportation. Clean transportation can help lessen the negative effects of transportation on the environment and promote sustainable development. According to Figure 4, conventional vehicles emit almost 300 grams per kilometer of greenhouse gases, while electric vehicles emit no more than 150 grams per kilometer (Huasfather, 2019). Therefore, the use of clean energy for transportation is crucial for reducing climate change (United States Department of Energy, 2023).

However, switching to clean energy for transportation still presents many challenges. According to Figure 5, the main challenge for electric vehicles is their shorter driving range. This, coupled with the insufficient charging stations, leads to competition for available spots and range anxiety (Glandorf, 2020). Other challenges mentioned in Figure 5 are that of the overall cost and battery cost. In addition to the challenges mentioned in Figure 5, there are also challenges regarding consumer awareness and policies. There is a lack of awareness among consumers, as most continue to have misconceptions about cost and effectiveness (Johnson, 2022). In terms of policy, while some nations have policies encouraging the use of environmentally friendly transportation, others do not. This leads to uncertainty among investors and results in delayed development (World Economic Forum, 2020). Even though switching to clean energy still presents many challenges, it is vital to mitigate climate change. Therefore, these challenges must be solved swiftly.

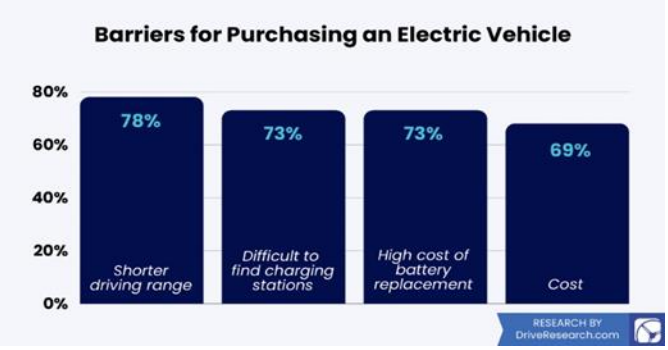

Figure 5 Barriers for purchasing an electric vehicle (Rodgers, 2023)

Climate change must be mitigated as it is a serious issue that requires urgent attention. Its consequences are already being felt strongly throughout the world. The primary contributor to climate change is the release of greenhouse gases as a result of the burning of fossil fuels. Clean energy emits minimal to no hazardous gases or pollutants. Therefore, one of the best ways to slow down climate change is by switching to clean energy; this will help the energy sector grow and lead to the discovery of new technologies. As a result, the demand for fossil fuels will decline and energy sources will be more diverse. The development of more effective policies and strategies for energy and the environment can be aided by research on the role of clean energy in reducing climate change. In studying how clean energy affects climate change, areas that require additional research and development can also be pointed out; this could result in technology that is more useful, affordable, and accessible (Jaiswal et al., 2022). Additionally, it aids in maintaining the accuracy of information about new regulations and technologies.

As one of the largest and most populous cities in Southeast Asia (ASEAN Up, 2017), Bangkok plays a significant part in climate change and mitigation. The effects of climate change, such as flooding, rising temperatures, and air pollution, are already being felt in Bangkok (Boyle, 2020; Gluckman, 2019). Bangkok is a party to the United Nations Framework Convention on Climate Change and has taken part in international climate change negotiations (Ministry of Foreign Affairs, Kingdom of Thailand, 2022). Nonetheless, Bangkok also contributes to greenhouse gas emissions, with transportation being one of the contributors. Most of those emissions come from vehicles used for transportation on roads, including cars and motorbikes (Phakdeetham, 2022). In addition to converting to clean energy vehicles, encouraging the use of public transit, particularly those powered by clean energy, can help lessen the effects of climate change associated with transportation in Bangkok.

While there are numerous ways to get around in Bangkok with public transport, only some services use clean energy. For taxis, the majority still use gas, while only a small number use electric cars. The project for electric buses started in recent years; however, the project is still ongoing, and only some routes have been covered. In comparison, trains appear to be the most ecologically sustainable, as the majority of lines use electric trains. However, this research will focus on the BTS and how it mitigates climate change in Bangkok. The reason that BTS is used as a case study in this research is because it has been certified by the Thailand Greenhouse Gas Management Organization (TGO) as the world's first and only carbon-neutral mass transit rail company (BTS Group, 2021). Moreover, the corporation is dedicated to increasing its energy efficiency by pursuing alternative energy sources and also intends to work with all sectors to achieve carbon neutrality by 2050 and net-zero emissions by 2065 (BTS Group, 2022a).

The role of clean energy and BTS in mitigating climate change is closely related to the Sustainable Development Goals 7 and 13. The usage of clean energy technology can aid in the reduction of greenhouse gas emissions and the improvement of air quality. It also grants communities access to inexpensive and dependable electricity; therefore, it is connected to Goal 7 "Affordable and Clean Energy" (United Nations Department of Economic and Social Affairs, 2023a). The BTS is also active in Goal 7 as the company studies and implements energy-saving measures, as well as follows environmental rules and regulations (BTS Group, 2022b). For Goal 13's "Climate Action", clean energy technology can help minimize the effects of climate change by reducing greenhouse gas emissions, and it also increases resilience and adaptive ability to climate-related hazards and natural disasters (United Nations Department of Economic and Social Affairs, 2023b). The BTS plays a role in

Goal 13 by developing a long-term climate strategy, managing climate risks and opportunities per the corporation's strategic priorities, as well as remaining a carbon-neutral corporation (BTS Group, 2022b).

With the threat of severe climate change looming, the study of clean energy and clean transportation has become crucial. To lower greenhouse gas emissions and mitigate climate change, it is important that clean energy becomes accessible and new technologies are developed. The role of clean energy in mitigating climate change is closely related to many areas of development. By lowering greenhouse gas emissions, enhancing air quality, as well as lessening the effects of climate change, clean energy technologies can contribute to environmental development (Acciona, 2019). The advancement of clean energy technologies can also open up new economic opportunities that can boost the economy. Finally, it can promote social development by strengthening energy security, lowering energy poverty, and expanding access to energy in remote and rural areas (Verma, 2023).

This research paper is divided into six sections. The first section describes literature reviews on clean energy, clean transportation, and government policies. The second section describes the main research objectives. The third section focuses on the methodology by describing detailed information about the participants in this research. The fourth section identifies research results, and the fifth section discusses findings from the research questions. The last section includes the conclusion and recommendations for this research.

1.1 Definition

1.1.1 BTS Skytrain

The BTS Skytrain is an elevated rapid electric railway in Bangkok, Thailand. It provides fast and convenient transportation across the city, which helps commuters avoid traffic congestion.

1.2 Climate Change in Thailand

Climate change has had a significant impact on Thailand, as it has on the entire world. The country is experiencing rising temperatures, altered rainfall patterns, and increased frequency of extreme weather events. For instance, according to the Office of Natural Resources and Environmental Policy and Planning (ONEP), from 2011 to 2021, Thailand's average temperature rose by 0.09°C annually, while the number of days above 35°C grew dramatically (ONEP, 2024). Thailand's climate change is mostly driven by global greenhouse gas emissions, with local factors worsening the situation (ONEP, 2024).

Rapid urbanization, particularly in cities like Bangkok, contributes to the urban heat island effect, which causes higher temperatures in built-up areas due to heat absorption by buildings and roads (ONEP, 2022). Furthermore, deforestation and land conversion for agriculture reduce carbon sinks and disrupt local climates (ONEP, 2022).

In addition, Thailand's agricultural sector, particularly rice agriculture and cattle rearing, produces a substantial amount of methane, which contributes considerably to Thailand's greenhouse gas emissions. Traditional practices, such as open burning of agricultural residue, increase greenhouse gas emissions (TGO, 2021). In addition, according to the Thailand Development Research Institute (TDRI), overuse of chemical fertilizers in agriculture can cause the release of nitrous oxide (N_2O), a powerful greenhouse gas (Kaosa-ard, & Pednekar, 1996).

Furthermore, Thailand's industrial activities, particularly energy generation and manufacturing, contribute significantly to the country's CO_2 emissions. The high percentage is due to the use of fossil fuels for energy generation and the expansion of industrial zones without proper environmental regulations (ONEP, 2022).

Moreover, the increasing number of automobiles, especially in metropolitan areas, leads to higher fossil fuel use and CO_2 emissions. Inadequate public transportation infrastructure worsens the dependency on private vehicles (Kaosa-ard, & Pednekar, 1996). Transportation accounts for nearly 30% of Thailand's total carbon emissions, which surpass 80 million metric tons per year (TDRI, 2024). Without intervention, emissions might rise to 110 million tonnes by 2030 and double 2.5 times by 2050 (Kaosa-ard, & Pednekar, 1996).

Finally, inefficient waste management methods in Thailand, such as open dumping and inadequate landfill operations, have a substantial impact on methane emissions and local pollution. The lack of comprehensive waste segregation and recycling systems adds to the problem (ONEP, 2022). Furthermore, the Pollution Control Department (PCD) states that poor landfill operations can cause leachate leaks, damaging soil and water resources and contributing to environmental degradation (Ramungul, & Boontongkong, 2017).

In conclusion, Thailand's climate change research reveals a complex interplay of global effects and local actions. Key contributors include emissions from the energy, industrial, transportation, agriculture, and waste sectors, all of which are exacerbated by unsustainable development and inadequate infrastructure.

1.3 Clean Energy

As the world faces worsening climate conditions and the threat of an energy crisis, it is vital to shift away from traditional energy sources and toward more sustainable ones. Clean energy is one of the primary solutions to this problem (Iberdrola, 2023). According to the latest International Energy Agency (IEA) (2023) data, global renewable energy capacity is forecast to increase by one-third this year, with solar power accounting for more than two-thirds of the increase. This is due to a variety of policies, rising traditional energy prices, and concerns about energy security. It is expected that growth will continue in the coming year, with global renewable energy capacity reaching 4,500 gigawatts (IEA, 2023).

On a smaller scale, the Southeast Asia region faces decarbonization challenges as the economy expands. Higher energy consumption and energy affordability present challenges for the region. To solve these issues, as well as the increased occurrence of natural disasters and extreme weather due to climate change, the region has to invest more in renewable energy (Fallin et al., 2023). However, these investments will be extremely costly, and while the private sector has undertaken certain projects, these large-scale investments are too expensive for them to carry out on their own. Even still, regional governments are unwilling to incur additional debt, especially after the pandemic (Fallin et al., 2023).

Thailand's energy production is primarily reliant on traditional sources. The Thai government has declared, however, to be carbon neutral by 2050 and to achieve net-zero greenhouse gas emissions by 2065. Its national energy strategy for 2022 likewise seeks to produce half of its electricity with clean energy by 2040 (Fallin et al., 2023). Furthermore, Thailand has significant potential for generating energy through solar power. According to the country's Power Development Plan 2018–2037, solar power is predicted to account for more than half of the country's energy by 2037. The world's largest solar farm, the first of 16 planned, began operations in the country's northeastern province in 2021. Furthermore, Thailand has extensively promoted the Bio-Circular-Green Economy, which entails the possibility of producing renewable energy from agricultural waste (Fallin et al., 2023).

1.3.1 Clean Energy and Climate Change Mitigation

Since the 1880s, climate change has been occurring at a faster rate than natural rates, due to human activities such as the burning of fossil fuels to generate energy. The combustion of fossil fuels leads to a rapid rise in CO2, while the emission of greenhouse gases traps heat in the earth's atmosphere (Intergovernmental Panel on Climate Change (IPCC), 2011; United Nations, 2023b). Therefore, traditional energy sources are unsustainable and play a big role in climate change (IPCC, 2011; Suman, 2021).

For this reason, worldwide frameworks and agreements such as the Sustainable Development Goals and the Paris Agreement have been formed to mitigate climate change. These frameworks and agreements refer to three crucial actions that aid in the fight against climate change: reducing emissions, adapting to climatic impacts, and financing necessary modifications (United Nations, 2023b).

The progressive development of clean energy has reduced carbon dioxide emissions and greenhouse gas emissions (IPCC, 2011; Suman, 2021). In addition, IPCC. (2011) and Suman (2021) pointed out that clean energy can reduce air pollution and other environmental repercussions, as well as enhance general health. Therefore, the effects of climate change can be mitigated by shifting to renewable energy and limiting the use of fossil fuels (White, 2021). Apart from environmental benefits, clean energy also has positive effects on the social, economic, and health sectors (IPCC, 2011; Suman, 2021). Clean energy sources play a significant role in sustainably delivering energy; the benefits of clean energy are large at all levels (IPCC, 2011; Suman, 2021).

However, according to IPCC. (2011), for clean energy supplies to be sustainable, they must be inexhaustible, economical, and aligned with societal needs and values. White (2021) pointed out that while renewable energy was formerly more expensive, it has become more affordable. As a result, this should aid in the economy's transition away from traditional energy sources. However, clean energy today accounts for only a small portion of total energy output. More must be done, and its contribution must expand for it to make a difference (White, 2021).

1.3.2 The Advantages and Disadvantages of Clean Energy

The usage of renewable energy can help reduce carbon emissions and combat climate change, among other things. According to Papathanasiou (2022) and the United Nations (2023c), renewable energy can assist countries in managing climate change. It improves health and air quality. Large-scale renewable energy also delivers significant economic advantages to investors, governments, and consumers (International Renewable Energy Agency, 2017; Papathanasiou, 2022). By switching to clean energy, countries will also be able to broaden their economies. They can expand their energy access, protect themselves from erratic energy price fluctuations, and cut energy costs (International Renewable Energy Agency, 2017; Papathanasiou, 2022; United Nations, 2023c) Furthermore, it will increase job opportunities and overall employment in the energy sector (International Renewable Energy Agency, 2017; United Nations, 2023c).

However, it is crucial to recognize that renewable energy has some drawbacks. Kramarz et al. (2021) identified displacement consequences such as displacement by dispossession, displacement by degradation, and displacement through dependent development as an issue. This is due to the global increase in demand for the metals and minerals needed in renewable energy systems. Hayward (2022) also mentioned some issues with sustainable energy. According to the author, clean energy might cause floods and kill animals. A large amount of land is required, and the materials will jam landfills. The author further claimed that renewable energy is unstable and cannot be completely relied on. Furthermore, the way green energy is collected might even contribute to climate change. While Zehner (2012) discussed some of the benefits of clean energy, the author emphasizes that shifting to clean energy is not the solution to the problem, but rather a distraction from the true issue of energy overconsumption.

1.4 Clean Energy Policies

Since energy production accounts for more than one-third of global greenhouse gas emissions, energy generation methods must improve (Green Economy Tracker, 2023). Clean energy policies are critical for the world to transition from traditional to clean energy sources. This will help mitigate climate change and satisfy rising energy demand. These policies call for both methods to discourage the use of traditional sources and financial support for clean alternatives (Lu et al., 2020; Green Economy Tracker, 2023).

According to the research by Lu et al. (2020), feed-in tariffs have proven to be effective in boosting clean energy in a variety of countries. This, in turn, discourages the use of traditional energy sources. In terms of financial support, both Lu et al. (2020) and the Organization for Economic Cooperation and Development (2013) suggested that investment in clean energy will need to expand to encourage the use of clean energy and help mitigate climate change. However, the lack of supportive regulations, as well as the outstanding barriers to international trade and investment, are primary impediments to clean energy investment flows. Therefore, governments and stakeholders must develop clear strategies to enhance the level of investment (Lu et al., 2020; Organization for Economic Cooperation and Development, 2013).

To develop effective policies, in-depth studies on clean energy policies must be done. While there are many studies on specific clean energy policies, very little is known about how successfully these various policies interact with one another (Fisher, & Preonas, 2010). According to Fisher, and Preonas (2010), these policies have overlapping jurisdictions and purposes. As a result, it is critical to examine these policies together rather than independently to determine if they complement or contradict each other.

1.4.1 Clean Transportation Policies

Transportation is a major contributor to carbon emissions. Currently, the majority of transportation is powered by traditional energy sources, such as fossil fuels. Shifting the transportation industry from traditional energy to clean energy sources is a critical step toward reducing carbon emissions and mitigating climate change (One Earth, 2023). A well-coordinated and integrated set of clean transportation policies is required to transition to a sustainable transportation system. In addition to reducing emissions, these strategies can enhance economic accessibility and improve quality of life (IEA, 2023).

There is widespread support for putting sustainable mobility at the top of the political agenda as policies encouraging the development of electric vehicles are critical to reducing CO2 emissions (Bardal et al., 2020; Nunes et al., 2019). Policy packages that include both push and pull measures, as well as policies boosting convenience in the usage of electric vehicles (EV), may be the most effective types of strategy. Monetary

incentives, as well as other measures such as road tax reductions and traffic regulations, could encourage the sales of EVs, while implementation of repressive laws, penalties, and taxes pushes consumers away from traditional vehicles. Furthermore, environmental concerns also play a significant role in consumer decisions (Bardal et al., 2020; Wang et al., 2017; Lieven, 2015). Additionally, the strategic use of communication, trials, as well as the implementation of the strategy step by step, can all be essential aspects of leading to a large success (Bardal et al., 2020).

However, there are challenges in establishing and executing these policies. The type and strength of challenges are influenced by the size of cities as well as the type of policies implemented. These initiatives and policies are insufficient to promote the widespread adoption of EVs because customer demand appears to be minimal. This demonstrates the need to investigate the relationship between policies and the acceptance of electronic vehicles (Bardal et al., 2020; Wang et al., 2017).

According to Heliox (2022), the Netherlands is an excellent example of clean transportation. The Netherlands came out on top in their study of intent and efforts toward the green transportation transition in the United States and Europe, with the most EV charger infrastructure and the lowest use of fossil fuels. Thailand, while on a different scale than leading countries in clean transportation, has increased its efforts to transition to more sustainable modes of transportation. The growth of the domestic electric vehicle (EV) industry is a critical pillar in this transition, with Thailand's EV market currently accounting for more than 60% of the region's market share. Furthermore, the government has issued numerous incentives to encourage the manufacturing and use of EVs (Fallin et al., 2023).

1.4.2 Thailand's Clean Energy and Clean Transportation Policies

Thailand has made a concerted effort to advance sustainable transportation and renewable energy regulations to lower greenhouse gas emissions and enhance air quality. Thailand aims to achieve carbon neutrality by 2050 and net-zero emissions by 2065. Achieving carbon neutrality by 2050 will require significant cuts in emissions from all economic sectors and steps to improve carbon removal from the atmosphere through carbon capture and storage, afforestation, and reforestation. In comparison to carbon neutrality, net-zero emissions aim to completely eradicate greenhouse gas emissions. Thailand's goal of having net-zero emissions by 2065 suggests that it intends to eliminate its greenhouse gas emissions (United Nation Climate Change, 2022).

The Ministry of Energy has launched several Renewable Energy Development Plans (REDP) to encourage the use of renewable energy sources like solar, wind, biomass, and hydropower. The REDP establishes targets for increasing the percentage of renewable energy in the country's energy mix (Ministry of Energy, 2015a). In addition, the Ministry of Energy has undertaken energy efficiency programs to minimize energy usage in a variety of sectors, including industry, transportation, and construction. These programs include energy efficiency regulations and labeling, energy audits, and incentives for environmentally friendly technologies (Ministry of Energy, 2015b). Furthermore, the Ministry has adopted a biofuels mandate, which requires the blending of ethanol with gasoline and biodiesel with diesel to boost biofuel use and reduce greenhouse gas emissions from the transportation sector (Ministry of Energy, 2004).

The Ministry of Transport (2019) developed a strategy that encompasses several key priorities. Firstly, there is a focus on creating a comprehensive and environmentally friendly public transportation system. This involves developing infrastructure that is accessible to all, while also working towards reducing energy consumption and embracing clean energy solutions to minimize environmental impact. Secondly, the strategy emphasizes the importance of ensuring safety and security within the transportation sector. This entails enhancing and implementing standards and regulations to safeguard passengers and goods during transit. Thirdly, efforts are directed towards improving efficiency and capacity building within transportation systems. This includes initiatives to enhance competitiveness and drive economic growth through the optimization of transportation networks and services. Lastly, the strategy recognizes the significance of driving factors such as legal frameworks, regulations, and technological innovation. By refining legal systems and fostering innovation in transportation technologies, the Ministry aims to further advance the effectiveness and sustainability of the transportation sector.

In addition, Thailand's Energy Regulatory Commission introduced a Feed-in Tariff (FiT) system to encourage investment in renewable energy installations. To stimulate the growth of renewable energy sources, this system guarantees producers a fixed price for the power they create that is greater than the market price (Santos, 2022). Furthermore, Thailand's Board of Investment has been supporting the use of electric vehicles

(EVs) to reduce reliance on fossil fuels and minimize air pollution. The government provides incentives such as tax cuts, subsidies, and infrastructure development to encourage the production and usage of electric vehicles (Thailand Board of Investment, 2017)

Overall, Thailand's pledge to achieve carbon neutrality by 2050 and net-zero emissions by 2065 indicates its acknowledgment of the critical need to combat climate change, protect the environment, and create a sustainable future for current and future generations. Achieving these objectives will necessitate coordinated efforts, collaboration, and innovation from society, the economy, and the government.

All of these literatures emphasized the significance of implementing environmentally friendly transportation modes and technology to solve climate change and global warming. Some of the papers explored approaches for achieving sustainable transportation systems. They addressed the possible economic benefits of green transportation and emphasized the need for technical innovation and good management practices. Most emphasized the significance of taking into account external variables such as law, economics, and geography. However, this research will focus on how clean and sustainable energy helps minimize the effects of climate change in Bangkok, Thailand, as well as the influence of national and local policies on climate change and clean energy. The study will also examine how green public transportation, particularly the BTS, is better for the environment. In addition, the importance of renewable energy to Thailand's energy security will be investigated in this study as well.

2. Objectives

1) To examine how the Bangkok Mass Transit System helps mitigate climate change in Bangkok, Thailand.
2) To understand the effects of clean energy and clean transportation policies on climate change mitigation in Bangkok, Thailand.

3. Methods

The qualitative method was used to examine the role of clean energy and the BTS, as well as the effects of clean energy and clean transportation policies in mitigating climate change. This study used both primary sources from interviews and secondary data sources. Interviews with participants in the field of clean energy were conducted. Interviews are crucial for several reasons. Firstly, interviews allow for in-depth explorations. They offer the flexibility to probe and follow up on responses, facilitating a richer understanding of the subject matter. Interviews also allow the researcher to capture diverse perspectives by interviewing participants with different backgrounds, experiences, and viewpoints. Secondly, interviews can give the researcher insight into the context surrounding a particular phenomenon or issue. Lastly, interviews provide an opportunity for researchers to build trust and rapport with participants, which can encourage openness and honesty in their responses (Creswell, & Poth, 2017).

3.1 Participants

The researcher interviewed six participants who have either theoretical or practical expertise in clean energy and climate change. There are two groups of participants: Bangkok Mass Transit System (BTS) personnel and government officials.

3.1.1 Bangkok Mass Transit System (BTS) Personnel

The Bangkok Mass Transit System personnel participants were chosen based on three criteria. First, participants must have direct experience or knowledge related to clean energy or clean transportation, as their insight must contribute to the research. Secondly, the researcher seeks to include participants with diverse work backgrounds and experiences; this can enrich the data by providing multiple perspectives and capturing a broader range of insights. Lastly, participants must have at least 5 years of experience working in the company. Participants with extensive experience are relevant to the research topic as they can provide valuable insights and rich data.

Three participants were chosen from the Bangkok Mass Transit System. The first participant works as a project manager and oversees the projects for the BTS. The second participant works on planning environmental policies regarding clean energy. The last participant is a mechanic who specializes in electric trains.

3.1.2 Government Officials

The government official participants were chosen based on three criteria. First, participants must have direct experience or knowledge related to clean energy or clean transportation policies, as their insight must contribute to the research. Secondly, the researcher seeks to include participants with diverse work backgrounds and experiences; this can enrich the data by providing multiple perspectives and capturing a broader range of insights. Lastly, participants must have at least 10 years of experience working in the governmental sector. Participants with extensive experience are relevant to the research topic as they can provide valuable insights and rich data.

Three participants were chosen from the government's official category. The first participant is a government officer in the Department of Climate Change and Environment. The second participant is a government officer in the Department of Alternative Energy Development and Efficiency. The last participant is a government worker in the Bangkok Metropolitan Administration.

Table 1 List of Interviewees

No.	Participant	Position	Organization	Category
1	Participant A	Director	Department of Climate Change and Environment	Government Officials
2	Participant B	Renewable Energy Specialist	Department of Alternative Energy Development and Efficiency	Government Officials
3	Participant C	Head of Railway Project Group	Traffic and Transportation Department Bangkok Metropolitan Administration	Government Officials
4	Participant D	Project Manager	Bangkok Mass Transit System	BTS Personnel
5	Participant E	Environmental Policy Planner	Bangkok Mass Transit System	BTS Personnel
6	Participant F	Train Mechanic	Bangkok Mass Transit System	BTS Personnel

3.2 Data analysis

This research employed a thematic analytic technique to examine the ways in which clean energy and clean transportation policies, as well as the Bangkok Mass Transit System, contribute to climate change mitigation in Bangkok, Thailand. Thematic analysis is one of the techniques used for examining qualitative data. It identifies recurring themes and patterns in textual data, such as transcripts or interviews (Braun et al., 2022). After carefully reviewing the information gathered from secondary research and interviews, the researcher identified recurring themes, subjects, concepts, and patterns.

4. Results

The results look into the participants' responses and are divided into 6 sub-topics, which demonstrate the relationship between climate change and clean energy, as well as the role of policies in mitigating climate change.

4.1 The Growing Threat of Climate Change

The dangers posed by climate change have increased in severity throughout the years. Climate change is causing two key rising threats: an accelerated rate of climate change and more frequent and severe natural disasters.

The first threat is that the climate is changing more rapidly than anticipated. In the past, the climate changed gradually. However, in recent years, the climate has noticeably changed at a faster rate. All participants agreed that the environment has dramatically changed and is changing faster than anticipated. Participants explained that this is due to increased greenhouse gas emissions from fossil fuels and deforestation. All participants believed that climate change has a substantial impact on Bangkok, Thailand. Participant D (Personal Communication, April 5, 2024) explained that "Since Bangkok is a metropolis, it uses more natural resources and energy. This accelerated the rate of climate change". The faster rate of change is not only a dangerous threat in itself but also the root cause of four other threats: continuous temperature rise, variations in rainfall, rising sea

levels, and an increase in air pollution. Participant A (Personal Communication, March 25, 2024) explained that "The Industrial Revolution severely impacted climate change. The rapid growth of climate change began during the Industrial Revolution, and since then greenhouse gas emissions have increased by two to three times".

As the climate changes more rapidly, the temperature continues to rise at a faster rate. This is due to the heat that is trapped by greenhouse gases. All participants agreed that the temperature has continued to climb and is becoming increasingly dangerous. According to Participant C, the average temperature did not reach the 1.5°C limit last year; however, it is quickly approaching it this year. Participants A and C went on to explain that temperatures in some areas have risen by 1.5 - 1.7 degrees Celsius over the last year, while the world average temperature has risen by 1.1 degrees Celsius this year. Participant A (Personal Communication, March 25, 2024) also stated, "While the temperature has been increasing each year, it has gotten much more severe this year. The heat rays have become stronger to the point where they are now burning upon contact". In addition to the rising temperature, there are also noticeable changes in rainfall and sea levels. The amount of rainfall has become unpredictable, and sea levels have risen. Participants A and E explained that as temperatures rise, glaciers are melting. This, along with excessive rainfall in some areas, has resulted in rising sea levels, which impact coastal towns and cause flooding and erosion. According to Participants A, B, and F, the constant rise in temperature causes turbulence and unpredictable weather. This causes rainfall changes, which have varying effects on different regions. Participant C (Personal Communication, March 29, 2024) stated, "Some regions receive more rainfall, causing sudden floods. Others face droughts, resulting in a lack of water".

Furthermore, the rapid rate of climate change leads to an increase in air pollution. Pollutants such as greenhouse gases, CO2, and PM2.5 directly affect the quality of the air. Participants C, D, E, and F stated that burning fossil fuels and starting forest fires increase air pollution and PM2.5 levels. This leads to increased greenhouse gas emissions, which further trap heat. Participant D (Personal Communication, April 5, 2024) explained that "The increase in greenhouse gases, CO2, and PM 2.5 is causing environmental and health issues. The dangerous quality of air is causing a variety of illnesses, including respiratory ailments and cancer".

The second threat is frequent natural disasters. As the climate changes more rapidly, natural disasters are becoming more frequent and severe. All participants agreed that natural disasters are becoming more dangerous as the effects of climate change worsen. According to Participants A and F, climate change causes severe weather occurrences such as thunderstorms, typhoons, and hurricanes. According to Participant C (Personal Communication, April 29, 2024), hot and dry weather can cause forest fires: "The continual rise in temperature, combined with the drought caused by rainfall fluctuations, results in more intense and frequent fires".

To summarize, the rising challenges of climate change pose a major global concern, as evidenced by two different threats that require immediate attention and action. From the rapid rate of change that leads to a rise in temperatures, shifts in rainfall patterns, rising sea levels, and the surge in air pollution to the frequency and severity of natural disasters, each threat highlights the complex relationship between human activity and environmental consequences.

4.2 The Role of Clean Energy and Clean Transportation in Mitigating Climate Change

The use of fossil fuels, particularly in transportation, emits a considerable amount of CO2 and greenhouse gases, contributing to climate change. As a result, climate change mitigation depends significantly on clean energy and transportation. Clean energy and clean transportation play two important roles in climate change mitigation: reducing greenhouse gas emissions and lowering energy prices. All participants believed that switching from fossil fuels to clean energy sources would help to reduce climate change.

The first role is to reduce greenhouse gases. By switching from fossil fuels to clean energy, greenhouse gases will be reduced. In addition, the temperature will decrease, and overall health will improve. Energy derived from the combustion of fossil fuels emits large amounts of greenhouse gases, including CO2, which participants agreed are the primary causes of climate change. One of the biggest contributors to this is transportation powered by fossil fuels, as Participant C (Personal Communication, April 29, 2024) pointed out: "Bangkok faces the problem of excessive CO2 and greenhouse gas emissions as a result of its heavy traffic". According to Participant F, as more fossil fuels are used, more greenhouse gases that trap heat from the sun in the atmosphere are produced. This causes the temperature to rise. As stated by Participant E, using fossil fuels emits hazardous gases and pollutants. Participant E further explained that these gases and pollutants, such as PM 2.5, can cause a variety of health issues, including respiratory illnesses. Participant C (Personal Communication, March 29, 2024) stated that

"Clean energy and transportation do not emit CO2, greenhouse gases, or pollution. Therefore, they will reduce health risks and improve people's quality of life". According to Participant A (Personal Communication, March 25, 2024), "While the current trend of clean energy is focused on electric vehicles, the future will be in natural energy sources such as hydropower or solar cells". Switching from fossil fuels to clean energy in all industries, particularly transportation, will drastically reduce greenhouse gases and, in turn, global temperature. Additionally, it will result in less carbon and pollutants being emitted into the atmosphere. Therefore, it has benefits for the population's health.

The second role is lowering energy prices. Aside from the environmental benefits, using renewable energy can reduce energy costs. While switching to clean energy may increase short-term energy expenses, Participant A believes it will save money in the long run. As the market for clean energy and transportation expands, new technologies emerge, resulting in lower production and consumption costs. According to Participant A, new nuclear technology is now in development. Participant A (Personal Communication, March 25, 2024) reported that:

> There have been recent efforts to produce small- particle nuclear technology that is not dependent on large nuclear plants. These small- particle nuclear technologies could be utilized in homes. However, the technology is still new and, therefore, a long way from being fully developed.

In conclusion, the transition from fossil fuels to clean energy and transportation systems plays an important part in the efforts to mitigate climate change. As all participants agreed, this change has the potential to reduce greenhouse gas emissions, lower global temperatures, improve public health, and reduce energy costs. Notably, the transportation industry, a major source of emissions, stands to benefit considerably from this transformation. Embracing sustainable energy solutions can drastically reduce emissions and contribute to a more sustainable future.

4.3 BTS Involvement in Mitigating Climate Change in Bangkok

The Bangkok Mass Transit System (BTS), often known as the BTS Skytrain, is critical to decreasing greenhouse gas emissions and combating climate change in Bangkok, Thailand. To help mitigate climate change, the BTS has developed three key climate change policies: reducing greenhouse gas emissions via electric-powered trains, monitoring greenhouse gases using the ISO 14001 standard, and conserving and managing energy.

The first policy is to reduce greenhouse gas emissions by implementing electric-powered trains. The BTS is a public transportation system that runs on electricity; as a result, it produces fewer pollutants than vehicles that run on fossil fuels and has a lower carbon footprint. According to Participant D, the BTS runs fully on electricity, including lighting, air conditioning, and engines. However, according to Participant F, since the electric system is turned off for maintenance, the rails are maintained using fossil fuel-powered vehicles. In addition, Participant E (Personal Communication, March 25, 2024) stated that "The BTS serves to minimize private car usage, which relieves traffic congestion and lowers CO2 emissions, PM 2.5, nitrogen oxide, and sulfur dioxide". Furthermore, Participant D (Personal Communication, March 25, 2024) stated that:

> BTS is the first and only rail transportation company that is carbon neutral. It is ranked first in the Dow Jones Sustainability Indices (DJSI). According to the S&P Sustainability Yearbook 2024, BTS also leads the transportation industry in terms of sustainability.

The second policy involves monitoring greenhouse emissions using the ISO 14001 standard. The BTS has an energy committee, which oversees the company's energy use. This committee works with the Ministry of Energy to mitigate climate change. According to Participant D, the committee has accepted ISO 14001, an internationally recognized standard that provides the requirements for an environmental management system. The participant further explained that ISO 14001 assists the BTS in keeping track of its greenhouse gas emissions to not exceed the guideline limits. In addition, Participant D (Personal Communication, April 5, 2024) stated that "Through the ISO 14001 system, BTS measures the use of energy and oil, the output of waste, as well as the carbon emissions from employees' methods of transportation to work".

The third policy is energy savings and management. The BTS has made efforts to lower the use of energy as well as switch to cleaner sources. As mentioned by Participant E, the BTS challenges itself monthly to lower

the building's power usage to conserve energy and battle climate change. Additionally, preparations are underway to replace purchased electricity with solar cells for the buildings' electrical systems. However, Participant F stated that using solar cells to power trains is currently unfeasible due to the high energy that is required.

In conclusion, the BTS plays an important role in sustainability in Bangkok, Thailand, with its policies aimed at reducing greenhouse gas emissions. The BTS demonstrates a commitment to mitigating climate change by using electric trains, adhering to ISO 14001 standards, and promoting energy conservation. The BTS's proactive approach highlights its critical role in promoting a greener urban environment that benefits overall health and serves as an example of sustainable transportation.

4.4 Clean Energy Policies

Clean energy is crucial to climate change mitigation; therefore, policies that promote it must be developed. These policies should focus on five areas: the industrial sector, energy production and consumption, technology and infrastructure, transportation, and the environment.

The first area is the industrial sector. The industrial sector is a sector that requires a huge amount of energy. Therefore, it is crucial to switch from fossil- generated energy to clean energy. Participant A claimed that a mandatory carbon market that demands clean technologies to avoid taxation would help cut carbon emissions. Additionally, green industries, green bonds, and green taxation policies can help the industrial sector switch to renewable energy. Participant A (Personal Communication, March 25, 2024) said that the industrial sector has undergone a rapid transformation: "Because of the need to conduct business on a global scale, the industrial sector is currently moving faster toward clean energy than the government sector". However, Participant A believes that because SMEs are having problems transitioning, the government should support them.

The second area is energy production and consumption. The production of energy must be done through means that are sustainable for the energy consumption to be clean. Participant B believes that by increasing renewable energy consumption to at least 50% of total electricity generation, the cost of renewable energy will likely fall. This, paired with the use of energy-storage devices, can help mitigate climate change without increasing the long-term cost of electricity production. Participant B (Personal Communication, March 26, 2024) explained that:

> This goes in line with our 4D1E plan, specifically the first, third, and fourth D. The first D stands for decarbonization, which promotes the production and use of clean energy to reduce air pollution and greenhouse gas emissions. The third D is decentralization, which encourages the spread of energy manufacturers and distributors as well as the development of local power plants. The fourth D is deregulation, which involves changing the laws and regulations so that the private sector can invest in power station businesses while also assisting local energy firms and releasing energy produced by the civil sector into the transmission system.

Furthermore, Participant C noted that the Bangkok Metropolitan Administration (BMA) promotes energy-efficient architecture and industry practices to reduce energy consumption and greenhouse gas emissions. The BMA also has initiatives to promote alternative energy consumption, including crop-based biofuel production and solar energy in buildings.

The third area is technology and infrastructure. To switch to clean energy, new technologies as well as sufficient infrastructure are needed. Participant B claimed that using modern energy management technologies and innovations can improve energy efficiency by 30%, hence improving energy management efficiency. Participant B (Personal Communication, March 26, 2024) went on to clarify that:

> This fits into the department's 4D1E plan, especially the second D and the one E. The second D is digitalization, which is to promote infrastructure investment and administration, elevate the electrical transmission line network into a smart system, and develop energy-storing systems. The E refers to electrification, which includes transforming the energy usage format to increase electricity usage, developing a modern electricity system infrastructure (grid modernization) managed by smart grid technology, modernizing electricity system prediction and control, and supporting energy production technologies.

The fourth area is transportation. As transportation is one of the leading sectors in greenhouse gas emissions, it is important that policies support the switch to clean transportation. Participant B claimed that increasing electric vehicle manufacturing by 30% by 2030 will transform transportation energy from fossil fuel-based to electricity-based. This will lower greenhouse gas emissions, increase energy efficiency in the transportation sector, and also combat PM2.5 air pollution.

The fifth area is the environment. Policies targeting environmental management can help lower the temperature as well as improve air quality. According to Participant C, the BMA supports having more green spaces, such as public parks and open spaces, to prevent heat accumulation and greenhouse gas emissions. Furthermore, the BMA has been working on waste management strategies to mitigate the consequences of climate change, such as pollution control and air quality management, in the region.

In conclusion, strong policies on clean energy and transportation are essential for combating climate change, particularly in the areas of industry, energy production and consumption, technology and infrastructure, transportation, and the environment. Carbon markets, renewable energy expansion, and green infrastructure are all important steps toward lowering greenhouse gas emissions and promoting sustainability. By tackling these critical issues thoroughly, Thailand can work towards a greener future while minimizing the effects of climate change.

4.5 Clean Transportation Policies

The emissions of greenhouse gases from fossil fuels used in transportation are a major contributor to climate change. As a result, strategies aimed at lowering fossil fuel consumption and alleviating transportation congestion are crucial. Four types of clean transportation policies can help alleviate climate change, including promoting electric vehicles and energy-efficient automobiles, supporting public transit development, encouraging energy conservation, and enacting traffic restrictions.

The first type of policy encourages electric vehicles and energy-efficient automobiles. By switching to electric and energy-efficient vehicles, greenhouse gas emissions will be reduced. Participant C suggested that policies should encourage the use of electric vehicles by assisting with the switch from a conventional vehicle to an electric vehicle. This can increase efficiency and minimize energy consumption in the transportation sector. Additionally, Participant C (Personal Communication, March 29, 2024) noted that “Bangkok Metropolitan Administration encourages the use of energy-efficient automobiles, and by approving traffic management plans and establishing more bicycle lanes to reduce private vehicle use, greenhouse gas emissions will be lower”.

The second type of policy supports the development of public transportation. To reduce the use of private cars, public transportation must be efficient, easy to access, and cover all areas. Therefore, the development of this sector is crucial. Participant C believes that developing transportation networks is one of the major solutions. Participant C (Personal Communication, March 29, 2024) stated that “By constructing a clean and efficient public transportation system, such as expanding the BTS and MRT rail systems, the use of public transit will increase while the use of private vehicles, which contribute to greenhouse gas emissions, will reduce”.

The third type of policy promotes energy conservation. While clean energy is essential for sustainability, energy conservation cannot be overlooked. Participant B explained that the implementation of mandatory energy conservation measures for all means of transportation can help reduce energy use while supporting climate change mitigation.

The fourth type of policy helps to enact traffic laws that can reduce heavy traffic, which significantly contributes to climate change mitigation. Participants B and C believe that policies managing traffic management, road traffic safety, and the use of private cars, such as limiting the number of private cars allowed into the city per day or collecting entry fees, can help reduce climate change.

In conclusion, addressing the significant contribution of transportation to climate change requires the implementation of effective policies. Promoting electric vehicles, funding for public transportation expansion, encouraging energy savings, and enacting traffic laws are critical for reducing greenhouse gas emissions and air pollutants.

4.6 Challenges in Implementing Clean Energy and Clean Transportation Policies

Mitigating climate change in Bangkok can be difficult due to the city’s high pollution levels and greenhouse gas emissions. To overcome this issue, policies that promote clean energy and transportation are vital.

However, there are six challenges to establishing and implementing policies, including data collection difficulties, technological and financial constraints, insufficient connecting points for rail systems and commute fares, opposition to policy development, a lack of public support and engagement, and the unexpected outcomes of climate change.

The first challenge is the difficulty of gathering data since the information must be collected through various measures, including scientific sources. Policies must be formed based on credible and complete data. However, Participants A and C believed it may be difficult to gather clear and sufficient data to make educated decisions on climate change management.

The second challenge is technological and financial constraints. Developing new technology and infrastructure requires a substantial budget, which is not always feasible. Participant D (Personal Communication, April 5, 2024) explained that while electricity is generally cleaner than fossil fuels, not all sources of electricity are clean. "Some electricity is produced using fossil fuels or transported via vehicles powered by fossil fuels. As a result, it is critical to ensure that the entire process is clean". Furthermore, Participants A, B, and C noted that climate change mitigation solutions necessitate investment and infrastructure improvements, which can be costly in some cases or restricted by financial constraints. The government sector lacks sufficient funds, while the private sector needs profitable returns on investment.

The third challenge is a lack of connecting points for the rail system and commute fares. Convenience and affordability are important factors in promoting the use of public transportation; however, there are certain limitations. Participant F mentioned that connecting points for the rail system are not always possible because infrastructure development must follow the municipal plan to prevent damage to roads, buildings, and other essential infrastructure. Participant F (Personal Communication, April 5, 2024) also stated that "The public rail system cannot breach the roofs of people's houses or undermine building foundations simply to establish a connection to other rail stations". Due to a lack of connecting points, passengers must change routes more frequently, resulting in expensive commute fares in some cases. This creates a problem in which the rail companies cannot lower their fares, which makes it unaffordable for many passengers. Because of this, the government occasionally must depend on taxes to cover the gap in commute fares.

The fourth challenge is opposition to policy establishment. The process of policy establishment requires cooperation and agreement from many sectors. Nevertheless, there might be dissent and opposition from those negatively impacted by the policies and those encountering challenges in their businesses. According to Participants A and C, climate change policies take time to establish, and there may be pushback from people in the corporate sector who are affected by the policy. Participant B explained that promoting electric vehicles may have an impact on traditional automotive enterprises that rely on internal combustion engines, with ramifications for related industries such as automotive component production and associated labor forces.

The fifth challenge is a lack of public support and engagement. Meeting carbon reduction targets and improving environmental conditions necessitates public support and participation. As stated by Participant B, for policies to be effective, the general population must be prepared to adjust and change their behavior. Participant A mentioned that previously, many people denied the existence of climate change, believing it to be merely normal weather fluctuations that occur gradually. Fortunately, people have become more aware of the reality of climate change and its significant impact on their lives. In addition, Participant C pointed out that because climate change issues affect the environment and human health, it is imperative to raise public awareness of these issues.

The sixth challenge is the unforeseen consequences of climate change. Although there are regulations and initiatives aimed at mitigating the effects of climate change, it is uncertain if these will be sufficient to address the current problems. As such, it is unclear what the future will bring, given how quickly climate change is accelerating. Participant A (Personal Communication, March 25, 2024) stated, "It remains uncertain whether these measures and policies will aid in restoring the climate to its former condition. Consequently, besides efforts to mitigate climate change, it is imperative to devise adaptation strategies, such as employing heat-reflective materials or selecting sites located in areas less prone to disasters".

In summary, implementing clean energy and transportation policies in Bangkok faces significant challenges, such as difficulties in data collection, technological and financial constraints, a lack of connecting points for the rail system and commute fares, policy opposition, a lack of public support and engagement, and unforeseen consequences of climate change. Although overcoming these challenges may be difficult, it is

necessary. To encourage sustainable behaviors and build resilience, these difficulties need to be addressed with cooperation and involvement from all stakeholders.

5. Discussion

In this section, the research findings will be discussed to answer the research questions. The primary source of this research will also be inserted to further explain and support the arguments of the research objectives.

5.1 The role of the Bangkok Mass Transit System in mitigating climate change in Bangkok, Thailand

The BTS's main role in mitigating climate change is to reduce greenhouse gas emissions and pollution. Its contribution to sustainable mobility is consistent with international efforts to tackle the pressing issues caused by climate change. Transportation powered by fossil fuels is one of the biggest contributors to greenhouse gas emissions. Therefore, it is crucial to switch to electricity-powered transportation. According to One Earth (2023), transportation significantly contributes to carbon emissions, primarily by burning fossil fuels. Ribeiro (2020) and Fallin et al. (2023) pointed out that shifting from traditional energy sources to clean energy sources in transportation can help energy conservation and management, as well as substantially reduce greenhouse gas emissions. Ribeiro (2020) further explained that the increase in electric transportation reduces carbon dioxide emissions while also increasing GDP in the long run. In addition, clean transportation leads to a reduction in air pollution by decreasing emissions of harmful pollutants, which have detrimental effects on human health (IPCC, 2011; Suman, 2021). Shah et al. (2021) also believed that clean transportation is critical in developing smart cities and smart tourism and should be viewed as the most efficient approach for attaining sustainable development.

Throughout the interview, it can be noted that BTS is aware that fossil-fuel transportation is one of the main contributors to greenhouse gas emissions and pollution. Therefore, the BTS made a conscious decision to power their train via electricity. According to Participant D (Personal Communication, March 25, 2024), the BTS is a public transportation system that runs on electricity; as a result, it produces fewer pollutants than vehicles that run on fossil fuels and has a lower carbon footprint. Furthermore, Participant D explained that BTS is the first and only rail transportation company that is carbon neutral and also leads the transportation industry regarding sustainability. Participant D further revealed that the BTS Energy Committee has accepted ISO 14001, which assists the BTS in keeping track of its greenhouse gas emissions to not exceed the guideline limits. In addition, Participant E (Personal Communication, March 25, 2024) stated that the BTS serves to minimize private car usage, which relieves traffic congestion. This, in turn, lowers greenhouse gas emissions and reduces air pollution. Participant E also mentioned the BTS's efforts to challenge itself monthly to lower building power usage and explore the use of solar cells for building electrical systems.

There is an effort worldwide to use electric vehicles to help reduce the effects of climate change. The Netherlands, Malaysia, the European Union, and China have each implemented notable initiatives in clean energy and transportation. The Netherlands stands as a pioneering model in clean transportation, boasting extensive EV charger infrastructure and a notably low reliance on fossil fuels. Through strategic investments and policies, the Netherlands has fostered a robust environment for electric mobility, facilitating widespread adoption of electric vehicles and reducing carbon emissions from transportation (Heliox, 2022). Similarly, Malaysia's 'Low Carbon Cities Framework' exemplifies a comprehensive approach to reducing carbon emissions and promoting sustainable urban transportation. By implementing initiatives aimed at enhancing public transportation infrastructure and encouraging the adoption of green vehicles, Malaysia seeks to create low-carbon urban environments conducive to sustainable living (Senin et al., 2021). The European Union's focus on promoting electric vehicles and reducing emissions from the transportation sector aligns closely with Thailand's clean energy and transportation policies. By incentivizing the adoption of electric vehicles and investing in public transportation infrastructure, the EU has made significant strides in reducing carbon emissions and combating climate change (Ribeiro, 2020). Furthermore, China's integration of energy and transportation industries underscores the importance of holistic approaches to carbon neutrality. By aligning energy and transportation policies, China aims to achieve carbon neutrality by 2060, emphasizing the role of clean energy and transportation in mitigating climate change (Teng et al., 2022).

In parallel with these global efforts, Thailand has made significant strides in transitioning to sustainable modes of transportation through initiatives like the Bangkok Mass Transit System (BTS). Operating solely on electricity, the BTS minimizes environmental impact by reducing emissions and pollution associated with

traditional fossil fuel-powered transportation. This commitment to clean mobility has positioned the BTS as a trailblazer in the transportation industry, garnering recognition as the first and only carbon-neutral rail transportation company in Thailand. The BTS Energy Committee's adoption of ISO 14001 certification underscores its dedication to monitoring and mitigating greenhouse gas emissions, aligning closely with Thailand's broader clean energy goals and policies (Participant D, Personal Communication, March 25, 2024). As Thailand aims to achieve carbon neutrality by 2050 and net-zero greenhouse gas emissions by 2065, initiatives like the BTS play a crucial role in realizing these ambitious goals. Through its support for electric vehicle adoption and the development of public transportation infrastructure, exemplified by initiatives like the BTS, Thailand stands poised to make significant contributions to global climate action.

In Thailand, the government's policies play a pivotal role in driving the transition towards clean energy and sustainable transportation. Thailand's ambition to achieve carbon neutrality by 2050 and net-zero greenhouse gas emissions by 2065 necessitates significant shifts in energy consumption and transportation. The government's proactive measures, including incentives for renewable energy adoption and the promotion of clean transportation, provide a robust framework for addressing climate change challenges. In alignment with the government's policies, the BTS serves as a key player in promoting clean and sustainable mobility. The BTS's operation on electricity and its commitment to environmental sustainability, as evidenced by initiatives like obtaining the ISO 14001 certification, resonate with Thailand's renewable energy goals (Fallin et al., 2023). By adhering to government directives and embracing clean energy initiatives, the BTS contributes directly to the reduction of carbon emissions and the mitigation of climate change impacts. Furthermore, the government's focus on energy efficiency and clean technologies finds support in the BTS's efforts to minimize its carbon footprint. The BTS's implementation of energy-saving measures and exploration of solar cells for building electrical systems are in line with the government's broader clean energy objectives (Organization for Economic Cooperation and Development, 2013). Through these collaborative efforts, the BTS actively supports the government's vision for a sustainable future by providing environmentally friendly transportation options and reducing reliance on private vehicles.

5.2 The Effects of the Clean Energy and Clean Transportation Policies on Climate Change Mitigation in Bangkok, Thailand

The adoption of clean energy and transportation policies in cities like Bangkok is critical to reducing climate change and its related effects. These policies are vital instruments in the battle against climate change. Two major effects of clean energy and transportation policies on mitigating climate change are the decrease of greenhouse gas emissions and pollution, as well as the enhancement of energy efficiency and security.

The first effect is a reduction in greenhouse gases and pollution. These policies significantly reduce pollution and greenhouse gas emissions by encouraging the use of sustainable modes of transportation and shifting away from traditional energy sources like fossil fuels (One Earth, 2023; United Nations, 2023b). To lessen dependency on fossil fuels, clean energy policies promote the transition to renewable energy sources, including solar power and bio-circular-green energy. This will lessen the release of greenhouse gases, which are a primary cause of climate change (Fallin et al., 2023; United Nations, 2023b). Additionally, since clean energy sources produce fewer pollutants than traditional energy sources, clean energy policies help reduce air pollution. In addition to enhancing Bangkok's inhabitants' quality of life, this decrease in air pollution also lessens the negative effects of climate change on public health (IPCC, 2011; Suman, 2021; United Nations, 2023b).

Furthermore, these policies cover transportation in addition to the energy sector. To mitigate climate change, clean transportation policies are crucial. They support Thailand's domestic electric vehicle (EV) industry, provide incentives for the adoption of EVs and the development of EV infrastructure, and support sustainable modes of transportation (Bardal et al., 2020; Fallin et al., 2023; One Earth, 2023). Clean mobility regulations help to lessen the city's carbon footprint and mitigate rising temperatures by lowering emissions from the transportation sector (IEA, 2023; One Earth, 2023). These policies help to enhance air quality and minimize vehicle-related pollution by putting in place measures like financial incentives, reduced road taxes, and traffic rules to encourage the use of EVs and other clean transportation modes (Bardal et al., 2020; Wang et al., 2017).

Moreover, green infrastructure initiatives are frequently incorporated into clean energy and transportation regulations, which increases their effectiveness in reducing climate change (Fallin et al., 2023; IEA, 2023). Urban places such as Bangkok can experience lower temperatures because of the cooling benefits and

shade that come with green infrastructure (Fallin et al., 2023; IEA, 2023). In addition, They also help to improve air quality and reduce air pollution (Fallin et al., 2023; IEA, 2023). For these reasons, the BMA has various policies that support having more green spaces, such as public parks and open spaces.

According to all participants, clean energy policies are essential in supporting the transition from fossil fuels to renewable energy sources across various sectors. The significance of encouraging the use of renewable energy in industries through mechanisms such as carbon markets and green taxation policies was highlighted by Participant A (Personal Communication, March 25, 2024). Furthermore, initiatives supporting alternative energy sources and architecture and industry energy efficiency have a critical role in lowering emissions and promoting sustainability (Participant C, Personal Communication, March 29, 2024).

At the same time, measures related to clean transportation are essential to reducing emissions from the transportation industry. To lower greenhouse gas emissions, Participant C (Personal Communication, March 29, 2024) emphasized the importance of promoting electric vehicles (EVs) and energy-efficient cars. Participant C further explained that a crucial tactic to promote a transition away from private vehicles is the development of effective and accessible public transportation networks. Furthermore, according to Participant C, enforcing legislation intended to lessen traffic congestion and promoting energy conservation measures help to reduce transportation-related emissions.

Through the shift from non-renewable energy sources to renewable ones and the encouragement of electric vehicles, these measures successfully lower emissions and minimize pollution. Reducing emissions related to energy production and consumption is made possible by the use of renewable energy in industries and the transportation sector (Participant A, personal communication, March 25, 2024; Participant B, personal communication, March 26, 2024). In addition, the implementation of traffic management techniques and the promotion of energy efficiency measures are factors that lead to a reduction in overall emissions (Participant C, March 25, 2024; Participant B, March 26, 2024).

The second is the enhancement of energy efficiency and security. The implementation of clean energy policies has been instrumental in driving the transition from fossil fuels to cleaner alternatives, thereby enhancing energy efficiency. These policies create economic opportunities, enhance energy security by reducing reliance on imported fossil fuels, lower pollution levels by investing in renewable energy infrastructure, and offer incentives for its use (International Renewable Energy Agency, 2017; Papathanasiou, 2022).

Moreover, the promotion of renewable energy sources facilitates greater energy access and affordability, particularly in underserved regions, therefore contributing to sustainable community development and poverty alleviation (United Nations, 2023c). Additionally, focusing on greener and more effective energy technology reduces energy waste, which raises overall energy efficiency (White, 2021).

In cities like Bangkok, energy consumption and traffic are further reduced by promoting energy-efficient modes of transportation like electric vehicles (EVs) and developing sustainable urban mobility solutions (Bardal et al., 2020; IEA, 2023). Furthermore, efforts centered around demand-response programs and smart grid infrastructure improve the efficiency of energy delivery and consumption, reducing energy waste in transportation and energy generation (Lu et al., 2020).

According to all participants, clean energy and transportation policies play a pivotal role in enhancing energy efficiency and security. Transitioning to clean energy sources and adopting cleaner transportation methods contribute to energy efficiency by reducing waste and optimizing resource utilization. For instance, Participant B (Personal Communication, March 26, 2024) stated that using modern energy management technologies and innovations can improve energy efficiency by 30%. Additionally, Clean energy technologies such as smart grids play a crucial role in enhancing energy efficiency by enabling better management and distribution of electricity. They allow for more efficient monitoring and control of energy flow, improving overall energy utilization. By incorporating advanced technologies, smart grids help integrate renewable energy sources more effectively into the grid.

As explained throughout the section, clean energy and transportation policies implemented by various countries serve as crucial instruments in mitigating climate change. The Netherlands stands out as an exemplary model in this regard, with extensive EV charger infrastructure and minimal usage of fossil fuels (Heliox, 2022). Similarly, Malaysia's "Low Carbon Cities Framework" initiative underscores the importance of sustainable transportation in reducing carbon emissions (Senin et al., 2021). Within the European Union, studies highlight the benefits of electric vehicles in curbing carbon dioxide emissions (Ribeiro, 2020). Additionally, China's ambitious

goal of achieving carbon neutrality by 2060 emphasizes the integration of energy and transportation industries (Teng et al., 2022). These international efforts collectively showcase the effectiveness of prioritizing sustainable modes of transportation and shifting away from traditional energy sources.

While Thailand might not be on the same scale as leading countries in clean transportation, has increased its efforts to transition to more sustainable modes of transportation. The growth of Thailand's domestic electric vehicle (EV) industry, currently holding more than 60% of the region's market share, showcases a commitment to reducing reliance on fossil fuels. Government incentives have been instrumental in promoting the manufacturing and usage of EVs (Fallin et al., 2023). Thailand's initiatives align with global trends in clean energy and transportation policies, emphasizing the importance of transitioning to renewable energy sources and promoting the adoption of clean transportation modes. By setting ambitious goals, implementing targeted policies, and investing in sustainable practices, Thailand is making significant strides towards achieving its climate objectives while contributing to global climate action.

Moreover, as previously highlighted, Thailand's clean transportation policies play a crucial role in mitigating climate change and reducing greenhouse gas emissions. By promoting electric vehicle adoption and investing in public transportation infrastructure, the government aims to minimize private vehicle usage and alleviate traffic congestion. These efforts are complemented by initiatives to manage traffic effectively and encourage energy conservation measures across all modes of transportation. Overall, Thailand's government-led initiatives and policies in clean energy and transportation align with international efforts to combat climate change (Fallin et al., 2023). By setting ambitious goals, implementing targeted policies, and investing in sustainable practices, Thailand is making significant progress towards achieving its climate objectives while contributing to global climate action.

6. Conclusion

The Bangkok Mass Transit System (BTS) emerges as a key player in mitigating climate change in Bangkok through its innovative use of electric-powered trains and strong commitment to sustainability. By significantly reducing greenhouse gas emissions and air pollution compared to traditional transportation methods, the BTS aligns with global climate initiatives and demonstrates the potential benefits of transitioning to clean energy in urban transit. The system's proactive measures, such as achieving carbon neutrality and implementing strict monitoring protocols, underscore its dedication to environmental protection. Moreover, the implementation of clean energy and transportation policies in Bangkok plays a vital role in enhancing public health and improving air quality, while also fostering energy security and efficiency. These policies support the adoption of renewable energy sources and promote sustainable mobility solutions, helping to alleviate traffic congestion and reduce overall carbon footprints. By reducing dependency on imported fossil fuels, these initiatives contribute to economic growth and resilience. Collectively, the BTS and the clean transportation policies it exemplifies not only support Thailand's ambitious goals for carbon neutrality by 2050 but also set a commendable standard for sustainable urban mobility on a global scale. As cities around the world grapple with climate challenges, the BTS serves as a model for integrating clean energy and transportation strategies, paving the way for a more sustainable future.

7. Recommendations

Climate change poses significant threats to the planet, impacting ecosystems and communities worldwide. Mitigation efforts are essential to reduce greenhouse gas emissions and curb the effects of climate change. This involves transitioning to clean energy sources, implementing sustainable practices in sectors such as transportation, and promoting conservation and adaptation measures. Clean energy and transportation policies are essential for effective climate change mitigation. These policies not only contribute to mitigating climate change but also foster economic growth, improve public health, and enhance energy security. Implementing comprehensive clean energy and transportation policies is vital for achieving climate goals and ensuring a sustainable future for generations to come. Therefore, the following recommendations are made to further aid in climate change mitigation.

Governments should prioritize the implementation and enforcement of clean energy and transportation policies, setting ambitious targets for renewable energy adoption and emissions reduction. Strong regulatory frameworks and incentives should be established to encourage investment in clean energy projects and the

adoption of electric vehicles. Additionally, public awareness campaigns should be launched to educate communities about the importance of these policies in mitigating climate change.

Resources for research and development in clean energy technologies and sustainable transportation systems should be allocated. Innovation and collaboration between government, academia, and the private sector should be supported as well. Furthermore, pilot projects and demonstration initiatives to test the feasibility and scalability of clean energy and transportation innovations should be invested in. In addition, international cooperation and collaboration on clean energy and transportation initiatives, including sharing knowledge, technology, and best practices to address climate change on a global scale, should also be fostered.

Local communities need to be empowered to participate in the planning, implementation, and monitoring of clean energy and transportation projects, fostering partnerships between government agencies, community organizations, and businesses. Equity and inclusivity in decision-making processes also need to be prioritized, ensuring that vulnerable and marginalized communities have a voice in shaping policies. Moreover, the social, economic, and environmental implications of interventions need to be considered, striving for equitable outcomes for all members of society.

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