Assessing the Prospects and Challenges of Hydroelectric Power Generation in Malaysia: A Multidimensional Analysis

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Abstract. Environmental problems have been growing over the past few decades, prompting many developing countries to explore green alternatives for energy generation and consumption, such as hydro power. This study wants to investigate the status of hydroelectricity in Malaysia across various dimensions and assess the policies and challenges associated with the hydro power industry. To begin with, a comprehensive literature review will be conducted, encompassing research papers and reports that delve into the current state of hydro power in Malaysia. Furthermore, this study will analyze the hydroelectricity sector in Malaysia from political, economic, social, and technological perspectives by employing a PEST analysis framework. This multi-faceted approach will provide a more holistic understanding of the potential impact that hydro power could have on the country. The study will also focus on the SCORE program, aiming to discern its environmental effects in terms of CO2 emissions. It can be tentatively concluded that hydro power appears to offer a promising path for power generation. However, the SCORE program does exhibit initial negative impacts. This situation may evolve positively in the future if challenges related to technology and politics are successfully addressed.

Keywords: Hydropower, PEST Analysis, SCORE, environmental impact.

1. Introduction

As power consumption in developing countries has grown significantly over the past few decades. Malaysia has plentiful nature resources and rich water due to its high annual rainfall, relies heavily on natural gas-fired and coal-based electricity generation. Therefore, the Malaysian government has set ambitious goals to increase both power generation and consumption percentages. Hence the government has claimed several plans, including SCORE program, aimed at achieving their goal of reaching carbon neutrality by 2050. However, this path is fraught with challenges, including the resettlement of affected communities and environmental impacts during the construction phase. By studying and learning from Malaysia's experiences, other developing nations, especially those facing similar circumstances, can adopt similar approaches. This discussion intends to investigate the current situation from political, economic, social, and technological perspectives using a PEST (Political, Economic, Social, and Technological) analysis framework. The research also discusses potential issues and environmental problems created by the SCORE scheme.

It is evident that political factors have had a significant impact on the program and the entire hydropower industry in Malaysia. The SCORE program has, at times, lacked a clear plan and has indeed resulted in major issues, including CO_2 emissions.

2. Current Situation

From 2000 to 2020, the Malaysia carbon emission has been increased for 103% according to Richie's research [1]. The rate of carbon emission of Malaysia has been considered as one of the highest among all the countries and it has archived the third place in the world, which is about 4.7% each year from 1970 to 2008. Malaysia, as a developing country, is heavily relied on non-renewable energy such as fossil fuel.

Rahaman et al. asserted that Malaysia has hydro power potential of about 123,000 GWh annually, but that barely a tenth of that capacity has been utilized and developed as of yet [2].

2.1. Power Generation

Hydro power accounts for only about 13% of Malaysia's electricity generation, stated by fig.1. In contrast, fossil fuel-based power generation comprises over 50% of the total, indicating a significant reliance on coal instead of renewable energy.

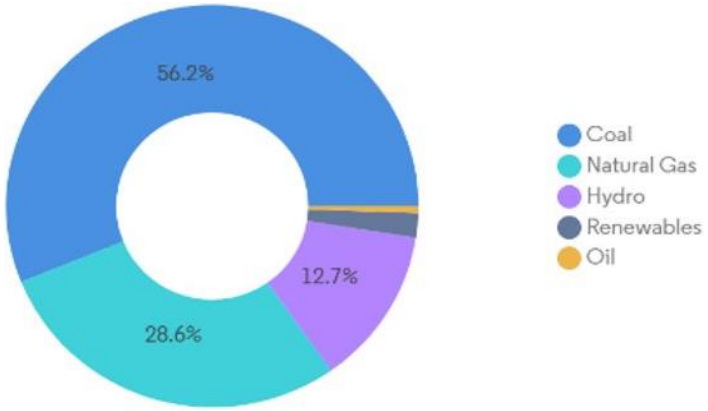


Figure 1. Power Generation in Malaysia, 2020 [3]

2.2. Power Consumption

As shown in fig.2, Malaysia's energy consumption demonstrates a similar but more concerning trend, with renewable energy constituting around 2% of power consumption in 2020 [4]. Gas, coal and oil were at a dominant position compared to hydro power, indicating the energy structure of Malaysia is occupied by non-green and heavily polluted energy resources.

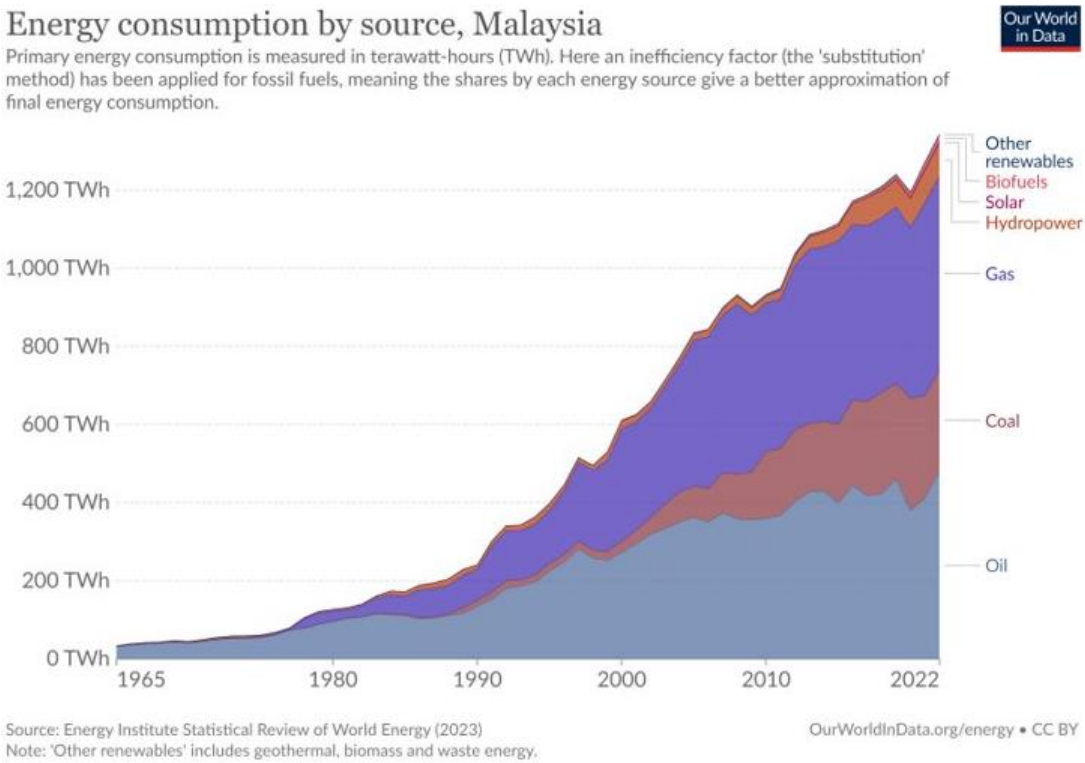


Figure 2. Energy consumption by source, Malaysia [4]

3. Analyzation of Malaysia Hydroelectricity

The Ministry of Economy of Malaysia has set targets of achieving 40% renewable energy in the power mix by 2035 and 70% by 2050. In addition, Malaysia also planned to reach carbon neutrality by 2050. Therefore, hydroelectricity is necessary.

3.1. PEST Analyzation

3.1.1. Political analysis

From the perspective of law and regulation, the change of competent government departments has also brought new changes to the hydroelectricity of Malaysia. Like many other developing countries, the rapid economic growth of Malaysia is mostly relied on the industrial sector. However, the industrial sector is highly depending on the availability of cheap energy supply. By investigating Bakun Hydroelectric Project, Sovacool and Valentine found out the governor are more prefer large-scale hydroelectricity project than smaller-sized projects as they believe the larger one could create more employments and cheaper energy supply, which would be necessary for industrial development and individual consumption [5]. And also, in many Asian counties, the large-scale project has been a way to measure the development and achievement made by government.

Corruption is also a hidden problem in Malaysia hydroelectricity industry. The massive investment in hydroelectricity sector and complex engineering project could be the breeding ground for corruption in different stages such as design and execution. The large amount of resettlement funds and compensation programs have been found to be a suitable place for corruption to occur, but worsen the situation of local people [6].

3.1.2. Economic analysis

As a developing country, the demand for energy will always increase with GDP growth and population growth [7]. Therefore, hydro power, as a commercially-available green energy technology on a large scale, is considered one of the most important solutions in Malaysia [8]. They also mention that the cost of hydroelectricity is one of the lowest, as electricity generation efficiency is the highest among all renewable energy sources. In theory, hydroelectricity will not change the nature of water when water is input through turbines and output, thus saving the cost of maintaining a clean environment [8]. However, the reality is much more complicated.

The SCORE (SCORE), one of the government's largest economic initiatives, aims to invest RM334 billion by 2030. The cost of this program is significant due to questionable procedures, including finding suitable positions for construction and the relocation of indigenous people. Delays and environmental impact assessments are also issues in this program, adding more pressure to the budget. An example is The Bakun Dam, estimated to be 600% over budget. An additional dimension involves the pervasive uncertainty surrounding power purchase agreements, alongside the persistent underestimation of risks encountered during the tender bidding process.

3.1.3. Social analysis

There are two main part of social effect is caused by the hydroelectricity project in Malaysia, which are resettlement and environmental effect. According to research carried by Ho et al. in 2020, 90% of the people who were invovled in government’s investigation are dissatisfied with their participation, while 80% of people stated that the government finished the process without following the procedures. This indicates that the right of indigenous people is violated by passing a project under the push of economic and environmental initiative[9]. This point is also proven in Aiken and Leigh’s essay in 2015, saying indigenous people and other vulnerable groups were removed from people from homes and ancestral lands without consents [10].

A significant portion of the species-rich tropical rain forest were destroyed by the projects, according to Aiken and Leigh's research [10]. Sovacool and Bulan stated that the generation of greenhouse gas emissions poses concerns for the broader climate impact of the initiative [11]. Downstream effects stemming from activities such as aluminum smelting and heavy manufacturing further extend the initiative's environmental footprint. SCORE results in carbon dioxide emissions and supports polluting industries. It also disregards water quality and risks. In conclusion, it contradicts Malaysia's energy policy and international standards [12]. DNHin his paper indicates that higher levels of urbanization correspond to heightened occurrences of flooding [13]. This pattern is

consistently observed, particularly in regions characterized by inadequately-drained soil types such as peat and clay.

Social challenges introduce a distinct layer of complexity, characterized by the phenomenon of boom-and-bust towns-locales experiencing rapid fluctuations in prosperity due to the project's dynamics. Furthermore, the imperative of community relocation and resettlement underscores the human aspect of the initiative, necessitating careful handling to mitigate social disruption and dislocation.

3.1.4. Technical analysis

One noticeable advantage is that the efficiency of modern hydroelectricity plants is approximately 85%, whereas traditional fossil fuel-based plants have an efficiency of only around 50% [14]. However, SCORE has severe technological difficulties. These technological challenges within the context of hydro power implementation encompass a lack of essential supporting infrastructure, including deficiencies in transportation and electricity networks. Moreover, there is a notable scarcity of skilled engineers and proficient construction workers, which hinders the smooth execution of projects.

One noteworthy technological advancement in the Malaysian hydroelectricity industry is the use of small-scale hydro power. It is defined as hydro generation capacity up to 10 MW [15], and it can produce and provide electricity for remote applications while emitting very little pollution. [15]. There is a possibility for 500 MW or less of modest hydro power in Malaysia's numerous dams and rivers. Importantly, small hydro power can provide electricity for rural areas, whereas large-scale hydro power is economically unfeasible for this purpose.

3.2. Case Study - Sarawak Corridor of Renewable Energy

The SCORE is introduced by the Malaysia government, aiming to tap into 51 potential hydro power sites with an estimated capacity of 20 GW [15]. For the Ninth and Tenth Malaysia Plan set by the government, it is one of the most crucial components. SCORE spans more than 100,000 km^2, covering about 80% of Sarawak, leveraging clean renewable energy to drive energy-intensive industries and attract investments. However, the project has encountered several problems and difficulties, as summarized by Sovacool and Bulan [13] across technical, economic, political, social, and environmental aspects. In this case study, I will mainly discuss the environmental side.

A hydroelectric power plant in a cold environment typically emits 15 g/kWh of greenhouse gases. The value is 30 to 60 times lower than the components of a plant using fossil fuels.

Environmental challenges are a facet to consider, with the initiative facing the consequences of deforestation as a result of construction activities. Furthermore, the generation of greenhouse gas emissions poses concerns for the broader climate impact of the initiative. Downstream effects stemming from activities such as aluminum smelting and heavy manufacturing further extend the initiative's environmental footprint. SCORE results in carbon dioxide emissions and supports polluting industries. It also disregards water quality and risks. In conclusion, it contradicts Malaysia's energy policy and international standards [11]. DNH in his essay indicates that higher levels of urbanization correspond to heightened occurrences of flooding [13]. This pattern is consistently observed, particularly in regions characterized by inadequately-drained soil types such as peat and clay.

As Fig.3 [16] has shown, Sarawak has lost 1.67 Mha of humid primary forest and total area is decreased by 22%. At the same time, according to Fig.4 [16], an annual average of 112 Mt was released into the atmosphere due to tree cover loss in Sarawak, resulting in a cumulative emission of 2.47 Gt of CO_2 [13]. This is partial caused by the SCORE as the program contributes to tropical deforestation [11].

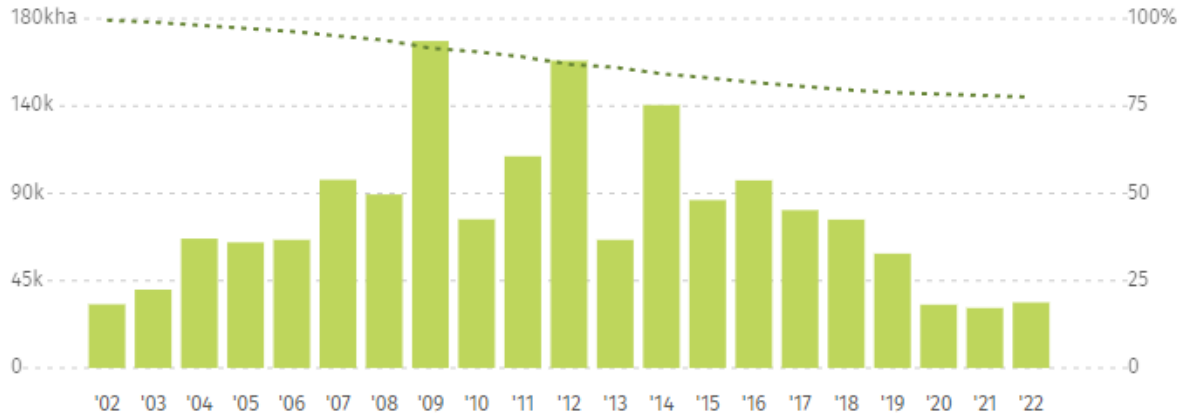


Figure 3. Primary Forest Loss in Sarawak, Malaysia [16]

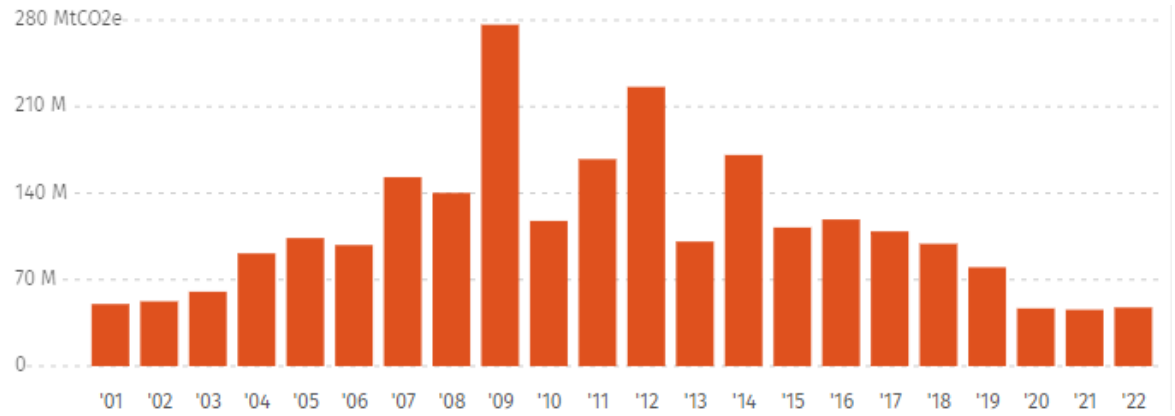


Figure 4. Forest-Related Greenhouse Gas Emissions in Sarawak, Malaysia [16]

4. Conclusion

Malaysia is a country with huge potential as abundant natural resources were suitable for the country to develop hydro power. Hydro power only occupies a small proportion of whole power generation and consumption but the target set by the Malaysia government of achieving net zero GHG earliest by 2050 is not unrealistic. The government actively took action and started to invest more funding in renewable energy programs such as the SCORE program. However, problems still exist in political, economic, social, and technological areas. In the political area, heavy corruption in many links such as resettlement and preference for large-scale programs caused by an overestimation of the effect of large-scale programs and obsession with political performance are two main problems preventing higher efficiency. Although hydroelectricity is a commercially available green energy technology on a large scale, the costs are high and many of them are wasted such as funding for Bakun Dam due to questionable procedures. The resentment is a huge problem when carrying hydro power programs and environmental issues such as carbon emission and deforestation are also concerning. In the technological area, problems still exist such as a lack of infrastructure, but the small-scale hydropower provides a new pathway to generate energy, especially for rural areas. Additionally, the SCORE program faces challenges, particularly in the environmental sector. The carbon emissions were enormous, contributing to tropical deforestation and disregarding water quality and risks. This contradicts Malaysia's energy policy and international standards. These problems have slowed the expected goal of carbon neutrality. However, if strong and effective governmental and societal supervision is ensured to prevent corruption and with careful consideration, the goal might be achieved. Reforestation also needs to be considered in the schedule.

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