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Article

Impact Of Covid-19 on renewable energy sector and lessons learned: A case study on Malaysia

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ABSTRACT

Coronavirus Disease 2019 (COVID-19) has been destructive in various sectors of Malaysia. In the renewable energy sector, Malaysia thrives in harvesting solar energy, biomass energy, and hydro energy, but despite years of development, the impacts of COVID-19 on these fields remain significant. This paper reviewed, analyzed, and summarized the effects of COVID-19 on the renewable energy sector in Malaysia. According to reviews, solar energy projects experience postponements as the import of solar panels is halted. At the same time, biomass saw its productivity reduced as workers were sent home as a measure to curb COVID-19. The same can be seen with the hydroelectric dams, where a single case may form a cluster which, once again, puts the entire project on hold. These are just some examples of the disastrous impact of COVID-19. However, there are positive impacts as well. The reduction in CO_2 emission and the investment in the renewable energy sector once fossil fuel drops its price are the same example testimonies. The future of the renewable energy sector after COVID-19 and the lessons learned from the impacts of COVID-19 are reviewed and presented in this paper as well.

1. Introduction

1.1 Main Renewable Energy Sources in Malaysia

An important element of every country that pushes their social and economic progress as well as being part of people's daily lives is "Energy" [1]. In terms of electricity and heat, energy is required globally as it serves as the basis for virtually everything that can be seen, lighting, transportation, electrical appliances, etc. Currently, fossil fuels, non-renewable energy sources (crude oil and natural gas), dominate the world's primary source of energy [2]. This holds true for Malaysia, where the country relies heavily on fossil fuel energy to ensure the country's social and economic growth. Hence, a constant supply of fossil fuel to run the industrial and transportation sectors must be met, which will eventually result in the depletion of these limited resources. Figure 1 indicates Malaysia's power generation fuel source in 1998 and 2018. From the chart, it can be concluded that Malaysia's power generation has increased by 27,242 ktoe (kilo tonne of oil equivalent). In 2018, most of the power generation fuel sources are mainly gas and diesel, which are non-renewable energy. Apart from its limited resources due to its low replenishing rate, fossil fuels' contribution to global warming and increase in carbon dioxide (CO_2) is alarming [3]. Hence, governments, including Malaysia, have taken initiatives to solve this problem by encouraging renewable energy to be implemented through various national programs. Renewable energy, in the form of sun, wind, hydro, and biomass, is defined as being able to replenish faster than it can be consumed. Should it be done well, renewable energy may replace the country's dependency on fossil fuels due to its eco-friendliness and emission of minimal amounts of CO_2. Evidence of slow but sure progress is depicted in the previous figure, where hydro has increased by 5%. The three main renewable energy sources in Malaysia, which are solar energy, hydroelectric, and biomass, will be introduced in the next section.

1.2 Ongoing Renewable Energy Projects in Malaysia

The Malaysian government aims to increase the renewable energy goal by 20% before 2025 [4]. Yeo Bee Yin, the former Minister of Energy, Science, Technology, Environment, and Climate Change, states that approximately RM33 billions investments will be required to achieve the target of 20% renewable energy generation. Most of the investment will come from the Malaysian government, and

others will come from partnerships with private companies [5].

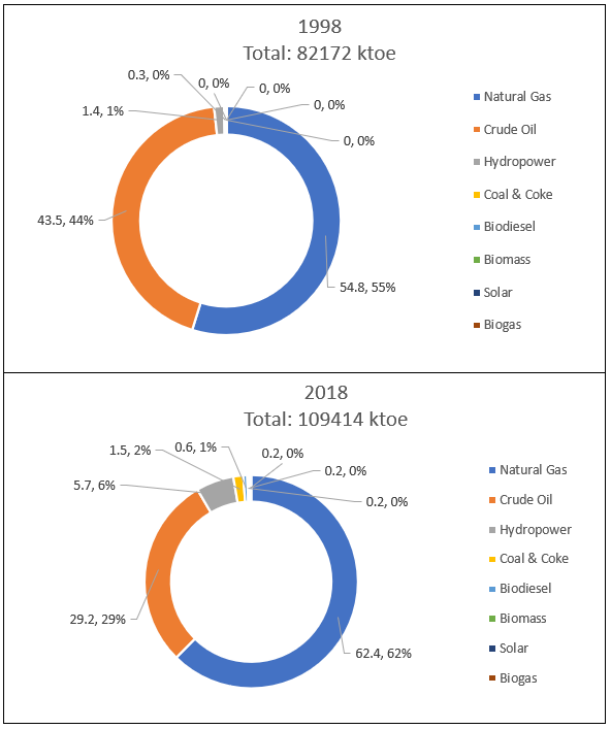

Figure 1. Energy Sources for Malaysia from 1998 to 2018

1.2.1. Solar Energy

Solar energy is abundant, free, and clean as it does not cause any pollution to the environment [1]. In Malaysia, the weather is generally on the hotter side as well as being humid throughout the year. The amount of annual rainfall depends on the seasonal monsoon though it is still generally present all year round [3]. The same can be said for solar radiation, where throughout the year, most places receive a mean daily solar radiation of approximately 4.7 – 6.5 kWh/m^2. Currently, multiple attempts have been made to harness solar energy through various methods, including solar collectors, sun trackers, and giant mirrors, to properly utilize it for industrial purposes. Solar photovoltaic (PV) systems have been advancing due to the abundant sunshine received in the country [1]. Because of these climate conditions in Malaysia, solar energy yields promising results for various applications and is slowly getting the attention of the citizens [3]. The government has also presented several innovative initiatives. These include net energy metering (NEM), feed-in tariff (FIT), and large-scale solar (LSS), amongst other various renewable energy incentives after realizing the potential of solar energy and other renewable energy in the country.

1.2.2. biomass

Biomasses are biological materials consisting of carbon, nitrogen, hydrogen, and oxygen obtained from living things. Given that the cycle of life will never break, this is another good limitless renewable source from animals and plants, hence the name bio-renewable resource [6]. Malaysia is known to envelope diverse tropical rainforests in Asia, and due to this strategic geographical location, the country will not encounter a lack of biomass anytime soon. By manipulating biomass in the form of wastes, biofuels and biochemicals that may be used in various industries have been discovered and manufactured over the last decade. Wastes in the form of rice husks, sawdust, and various biological waste materials may be burned to generate power as well, though generally for their respective processing [7]. On top of that, rubber wood was used by the furniture manufacturing industry, whereas sawdust was used to produce medium-density fiber (MDF) composite to produce wood. As seen in the diagram below, oil palm fronds contribute nearly half of the availability of biomass in Malaysia. Figure 2 shows the division of biomass availability per annum.

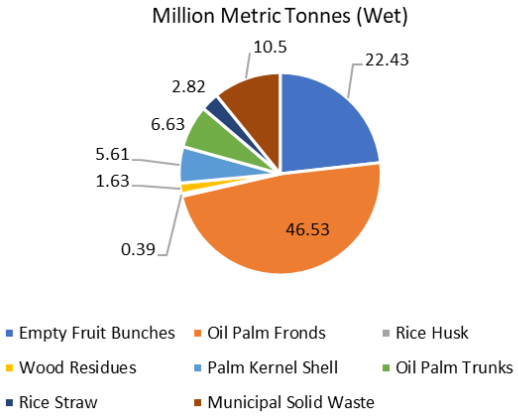

Figure 2. Annual biomass availability in Malaysia [7]

1.2.3. Hydroelectric Power

Currently, nearly 19% of the world's generated power is from hydropower, making it one of the most broadly used renewable energy sources [8]. Hydropower only utilizes water in its power generation system, which makes it a considerably clean energy source [9]. After generating electrical power, the water will be available for other purposes. Hydropower is one of the main sources of electricity in Malaysia, along with thermal stations and co-generation, whereby the growth of energy from hydropower has picked up significantly since 2010 [10]. There are sixty-two (62) total hydropower stations in Malaysia to date and a new large-scale 2400MW project in progress which is the Bakun project [8]. In total, Malaysia has a 18500MW of hydropower generation, which represents about one-fifth of the total generation capacity of Tenaga Nasional Berhad (TNB). TNB is the largest power utility company in Malaysia and was founded in 1990. Some examples of higher capacity hydropower plants across different states in Malaysia include Bakun Dam (2400 MWE), Murum Dam (944 MWE), Pergau Dam (600 MWE), Sultan Mahmud (400 MWE), and various other dams.

1.3 COVID-19 Pandemic

According to the World Health Organization, Severe Acute Respiratory Syndrome Coronavirus 2 (SARSCOV-2) in 2019, also known as COVID-19, is an infectious disease that causes a pandemic across the globe. This disease is highly contagious as it can be transmitted from one human to another human via droplets of saliva or discharge from the nose [11]. The effect usually includes mild to moderate respiratory illness. However, people with underlying medical problems will be more likely to develop even more serious illnesses. As of 20th March 2021, the World Health Organization states that there are 120 million confirmed cases with a total of 2.7 million deaths worldwide [12]. At the same time, Malaysia has a confirmed case number of 330 thousand with 1.2 thousand

deaths. Given that Malaysia has a population of 32.4 million, the percentage of the infected population stands at 1.02% [13]. The effect of COVID-19 on everyone everywhere can be summarized into three major categories: healthcare, economic and social. These three categories of effects disrupted Malaysia by challenging the healthcare system, damaging the nation's economy, and changing the country's social norms [14].

2. Effects of COVID-19 on the renewable energy sector

2.1 Emission

The country's effort to prevent the widespread of COVID-19 led to a Movement Control Order (MCO), which means that all travel, industrial and commercial activity is banned nationwide. There was a CO_2 emission reduction of about 8.8% in the first 5 months of 2020, with an annual reduction from 4% to 7%. It was found that CO_2, NO_2, and particulate matter (PM) were reduced as the rate of transportation was reduced as well. It was also found that the reduction in emissions also affected the weather and climate though it may be too insignificant to have any desirable impacts [15].

2.2 Solar Energy

There is a shortage in solar panel supply around the world due to the export ban in China. China is the largest producer of solar modules globally. In Malaysia, 8% of energy is generated by renewable energy. This number is expected to rise to 25% in 2025. The present impacts of COVID-19 are shortage of labor and professionals, project delays, investors quitting, and disruption of supply chains. Examples of solar energy companies in Malaysia are SolarVest, +Solar, Green Energy Resources (M), SOLS energy, and pathgreen energy. Before Covid 19, the installed capacity for solar energy in Malaysia will have an expected growth at a compound annual growth rate (CAGR) of more than 10% in the forecast period of 2021 to 2026. The installed capacity is expected to reach 2.07 GW in 2026 from 882 MW in 2019. Solar panels in Malaysia typically come from China. The Movement Control Order (MCO) restrictions with China during the COVID-19 period delayed the solar energy project in Malaysia. The Malaysian government postponed solar proposals, including a capacity of 1GW solar farm in 2020. On the other hand, due to the glass shortage in China, the manufacturing cost of solar panels increased. In June 2020, the manufacturing costs for the solar panel increased by 22% due to COVID-19. One of the impacts on solar energy in Malaysia is that the cost to purchase solar panels from China will increase, and it will be a major obstacle to the development of solar energy in Malaysia [16].

2.3 Biomass

The pandemic of Covid-19 has affected global health care badly [17]. The virus outbreak has caused a significant drop in energy demand. The agriculture sector contributes 12% of the national gross domestic product (GDP) besides providing employment to 16% of the population in the country, all of which sustains life in rural communities through extensive activities. However, the resilience of the agriculture sector has been tested by the pandemic as the price of rice has triplicated due to panic buying and storing of food products which are alarming for nations and consumers, including Malaysia, which imports 30% of its paddy consumption from different parts of the world [18]. Moreover, the countrywide lockdown implemented by the Malaysian government in March 2020 has posed challenges to the operation of many palm kernel shells (PKS) suppliers. The state government of Sabah has also imposed strict measures on the palm oil industry by imposing a lockdown on plantations and mills from 25th to 31st March 2020 to curb the movement of palm oil workers after several workers tested positive for the virus. Since Sabah is the largest palm oil producer in Malaysia, besides Malaysia being the second largest exporter of wood pellets and PKS in Asia, and with rice husk and PKS being the main components of biomass, this would impact the biomass sector in terms of the biomass output [19]. Not only that, despite the easing of Covid-19 restrictions in the country during May 2020, but biomass sector in the country also remains in a state of uncertainty as each state has the final say on whether the biomass operations can resume. This is mainly due to the economic reopening conditions and standard operating procedures (SOP) in Malaysia being unclear, thus causing biomass output to be unable to return to pre-lockdown levels [20]. On top of that, the travel restrictions imposed, which aim to prevent the spread of the virus, have caused a shortage of labor in Malaysia's palm plantations [21]. The country's plantation industry lost 500,000 workers due to MCO. Despite the potential impact on the biomass sector arising due to SOP uncertainty and shortages of the workforce, the easing of Covid-19 restrictions in the country is expected to increase the supply of wood pallets and PKS, which could bring certain benefits to the biomass sector [20].

2.4 Hydroelectric Power

Generally, 141,000GWh is the documented total gross hydropower potential (TGHP) per year, with 123,000GWh potentially under development. Sarawak dominates hydroelectric power at 71% of TGHP, with Sabah and Peninsular Malaysia following at 16% and 13%, respectively. In early 2020, fifteen (15) contractors were given small 176MW hydro development projects by the Sarawak Energy Development Authority (SEDA) and are expected to begin operations commercially in late 2025. In Sarawak, the focus is now on the Baleh Project, a 1285MW major hydro project, which is planned to be done in 2026 [22]. As of 28th April 2021, nearly one-third of the workers' 970 tested positive at the 1,285 MW Baleh project site. Although the project has introduced standard operating procedures (SOPs) and controlled the entrances of workers to curb the spread of COVID-19, a local worker broke the defense of this site as he has had contact with two Pasai Cluster cases. Mass testing was commenced immediately. This led to the discovery of a high number of positive cases among the workers. The project site was immediately given the lockdown order well before the Sarawak Disaster Management Committee (SDMC) announced the newer Enhanced Movement Control Order (EMCO). Although the impact of this shutdown was not stated in the news, it is believed that the shutdown of this site will bring a huge impact on the Sarawak Government [23]. Meanwhile, in Sabah, two hydropower projects that are yet to start, but have been planned, have been identified: The Upper Padas project and the Liwagu project. Without COVID-19, this project would have begun construction and possibly contributed to the national power grid [24].

3. Impact forecast of COVID-19 on the renewable energy sector

3.1 Solar Energy

Due to COVID-19, the price of oil has dropped dramatically, and many investors moved toward the renewable energy sector, which may push the solar energy sector to rise considerably in the world. Referring to the Malaysia Budget of 2021 and the success of the Green

Technology Financial Scheme, the government had allocated RM2 billion for its continuation. Malaysia's government would like to encourage all the private sector to participate in green technology, especially in the manufacturing and service industry. The government also encourages energy-efficient appliances, including solar panels, under the Save 2.0 program with an allocation of RM 30 million. Every household will receive RM 200 cash back when they purchase those energy-efficiency appliances [25]. Furthermore, the government has planned some long-term programs for the growth of solar energy, which include the National Solar Photovoltaic Monitoring System (PVMS), Supply Agreement for Renewable Energy (SARE) Programme, Large Scale Solar (LSS), Feed-in Tariff (FiT) for Solar Photovoltaic, Net Energy Metering (NEM) and Peer-to-Peer Solar Energy Trading (P2P). The government also aims to implement 9 GW of solar energy capacity around each state in Malaysia by 2050. This solar energy target will collaborate with some business models, such as leasing solar panels, to create opportunities in the future [26]. In Dengkil, Sepang District, SPIC Energy Malaysia Berhad, and Solarvest Holdings, Berhad successfully built a 13 MW floating solar farm in October 2020. A 13MW floating solar power plant was completed in Dengkil, Sepang District, by SPIC Energy Malaysia Berhad and Solarvest Holdings Berhad in October 2020. On top of that, Malaysian researchers suggested solar module cooling with reference to fin heat sinks in December 2020 to lower the payback times in the PV system and maintain the optimal temperatures of up to 26oC. In early 2021, applications for Net Energy Metering 3.0 program were opened by the Sustainable Energy Development Authority (SEDA) in Malaysia. All the solar energy companies are allowed to join the program to allocate 500 MW of rooftop PV capacity in Malaysia [16].

3.2 Biomass

Although the Covid-19 pandemic could affect the biomass sector in the short-term period, it could potentially bring several benefits to the sector in the future. One of the benefits includes introducing more job opportunities for locals in the biomass sector. Due to the shortage of foreign labor caused by travel restrictions, Mohd Khairuddin Aman Razali, the Minister of Plantations and Commodities, urged agricultural companies to recruit local workers. As the required number of workers is around 1 million, the current number of about 220,000 locals and 260,000 foreign workers is insufficient and affects the production of palm fruits negatively. Hence, the need to employ locals has become a priority even if previous employers did not have the incentive to hire locals and locals were uninterested in 3D (dirty, dangerous, and difficult) jobs [21]. Interestingly, graphene is one material that may help against COVID-19 and similar diseases. As filters and coatings, it has the potential to be one of the more effective materials to overcome Covid-19. Biomass materials that have shown to exhibit graphene-like properties have been utilized. For example, sugarcane water powder is shown to have superhydrophobic coatings with the appropriate nanostructures, which is highly important in the medical field where the prevention of contagious droplets from entering the lungs may be prevented. This may prove to be beneficial to the community in the fight against the pandemic by blocking COVID-19 droplets. As graphene has been known to be used in sensors, biomass-derived graphene can also be applied to create biosensors that may detect the presence of the virus in the human body. However, this remains impractical even though said properties of graphene are proven as more testing and studies must be done to determine its effectiveness [27].

3.3 Hydroelectric Power

Malaysia plans to have nearly 20% of renewable energy powering the country by 2025 (with 41% by 2050). This goal grows close the more Malaysians commit themselves to use renewable energy. A smart grid, a vital enabler for energy security and implementation of renewable energy resources, is essential to facilitate the integration of renewable energy into any power supply system. Hence, hydropower plants need to realize high efficiencies with enhanced technology to boost performance to penetrate the market of power systems [28]. Studies towards hydroelectric power have been done, but any in-depth studies remain missing. This provides future researchers valuable opportunities to further research and enhance existing, or even new, technologies to help push hydroelectric power development. In Malaysia, planning, design, delivery, and maintenance of hydroelectric power infrastructure are vital roles that professional services firms are given. SMEC, an example of a professional services firm, has been contributing to hydroelectric projects across the country since the 1970s, which has impacted the communities and economic activities significantly, even boosting tourism and other industries from time to time. An unexpected positive outcome that comes from developing hydroelectric power generators would be the opening of new roads providing access to new remote areas. This would be very suitable for economic or even tourism development; an example would be the Bengoh Dam in Sarawak, Malaysia. Sarawak government also will invest in Sarawak's first large-scale floating solar plant at the Batang Ai Hydroelectric plant [29]. Stakeholders are essential for hydroelectric power generators to thrive, and effort must be increased to engage them. Even though its investment rate is relatively high, the long lifespan with low operational and maintenance costs outweighs the initial cost, and this is a major point that stakeholders need to know about. On top of that, of all renewable energy resources, hydroelectric power is considered the best, with higher conversion efficiencies [30].

4. Discussion (lessons learned and predictions)

Learning from COVID-19 is part of a very important process of recovery from the pandemic. The renewable energy sector in Malaysia could very well improve in the near future. The following examples should be taken seriously; ultimately, further research may be applied to minimize, or even avoid, the negative impacts of another pandemic. Table 1 (Appendix) summarizes the content of this research paper, and some insights from the author are presented. As governments plan to end lockdowns, scientists warn of the risks of a second peak and the need to maintain significant social distancing measures until vaccination programs can be rolled out. How can power projects survive in this 'new normal? This section discusses some suggestions to overcome the mentioned issues and may help in future pandemics. The first projects would have some degree of freedom. Typically designing a highly specialized project is valuable; however, should any problem like COVID-19 affect its productivity, it may, in some other ways, cripple the company's profitability. Providing flexibility in these projects in the form of a multipurpose proposal or implementing redundancies. This way should a project deviate from the original goal due to external factors such as COVID-19, the company may minimize loss by redirecting attention towards other aspects of the project. Expansion of the project

timeframe is another way to minimize the potential impacts. Planning earlier and obtaining supplies earlier may help significantly when a potential material shortage is imminent, e.g., a pandemic is announced. Speaking of redundancies, companies may consider having backups that may be used whenever an obstacle presents itself. These backups may come in the form of additional workers or additional materials. That way should a group of workers fail to work due to any illness, another group may take over. Though this might reduce efficiencies if there are multiple projects present, it will allow a slow and steady pace in progress instead of a complete stop. Malaysia may even consider getting additional suppliers or contractors. This would allow the country to stop relying on imports from other countries and begin its own manufacturing process. For example, Malaysia has been importing solar panels from China, and if a pandemic shuts down all imports from overseas, this cripples any solar projects. However, should Malaysia manufacture its own solar panels, this problem would be easily solved. On the question of solving its own problem, Malaysia could shift more focus to training more specialized Engineers by pulling resources from different countries. By doing so, the development of the renewable energy sector would greatly improve with perspectives from various backgrounds.

5. Conclusion

COVID-19 has impacted the renewable energy sector in Malaysia but not necessarily negatively. Emissions have been found to be reduced due to the absence of Greenhouse Gas emitters. In terms of solar energy, the impacts are negative due to the lack of solar panel supply. This resulted in a shortage of labor, project delays, and disinterest among stakeholders. For biomass, the sales of palm kernel seeds have reduced significantly though the price of rice has almost tripled due to panic buying and hoarding. As biomass is still uncertain, the choice to continue or to restrict operations depends entirely on individual states. Hydroelectric generators in Baleh were halted due to confirmed COVID-19 cases though the implications of this shutdown were not published. Any project start-ups were delayed, such as The Upper Padas project and the Liwagu project, as the situation was very uncertain. The future of the renewable energy sector in Malaysia due to COVID-19 is still unclear though measures have been taken to recover this sector and to allow Malaysia to transit into cleaner energy production in the future. As of this article, some precautionary measures may be taken, such as giving some degree of freedom and having backup will help combat the negative effects of the pandemic and may even prepare the energy industry for the next global crisis. The authors would like to urge more research into the effects of COVID-19 on a global scale, especially on energy sectors, after some time, as the understanding of the long-term effect of such a pandemic is still immature.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language.

Data availability statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflict of interest

The authors declare no potential conflict of interest.

Authors' Contributions

Lo Chun Hui: Collected data, Wrote the manuscript., **Geoffrey Tan Kay Meng**: Collected data, Wrote the manuscript., **Hiew Li Jue**: Collected data, Wrote the manuscript., **Eden Voon Wu Qian**: Collected data, Wrote the manuscript., **Ateeb Hassan**: Reviewing, Editing., **Hadi Nabipour Afrouzi**: Contributed data or analysis tools, Reviewing, Formatting, Supervising., **Kamyar Mehranzamir**: Reviewing, Editing.

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Appendix

Table 1. A Summarized Table of Potential Lessons to Be Learnt

Lessons Learnt			
RE Sectors	**Current Impacts**	**Future Impacts**	**Future Projection**
Solar Energy	• Minimize reliance on other countries for manufacturing and begin local manufacturing processes. • Purchasing of additional solar panels in storage as backups.	• A drop in oil prices will result in solar panel investments. • Due to that fact, governments would place fewer incentives on fossil fuels to promote solar panel investments.	• Malaysia should see an increase in solar energy development, and a transition from fossil fuels may be expected as well.
Biomass	• Tripling the price of rice due to panic buying and storing, hence affecting the biomass output. • Countrywide lockdown implemented has affected the operation of palm kernel shell suppliers. • Labour shortages due to travel restrictions imposed.	• Introducing job opportunities for locals in the sector due to the shortage of foreign workers. • Biomass materials are used to prepare graphene-like materials which can be used on surgical masks besides being used in sensors to detect the virus.	• Local unemployment rates should see a drop as the local farmers are more accepting of local labor workers. • If more resources are devoted to developing and understanding graphene-like materials (derived from biomass), Malaysia may be the pioneer in inventing an organic virus detector.
Hydroelectric	• Health and safety measures need to be kept in check. • A single contagious case will spread and may cause the entire site to shut down	• Constant studies and research are vital to improving hydro efficiencies. • Malaysians should begin looking toward hydropower generation as Malaysia has an abundance of flowing rivers	• Hydroelectric development in Malaysia should still be able to proceed as planned, albeit with some delays due to this pandemic.