Scientific Review Engineering and Environmental Sciences (2023), 32 (1), 87–98

Sci. Rev. Eng. Env. Sci. (2023), 32 (1) https://srees.sggw.edu.pl

ISSN 1732-9353 (suspended) eISSN 2543-7496 DOI 10.22630/srees.3899

Received: 24.08.2022
Accepted: 05.01.2023

Shahrul Nizam MOHAMMAD[1]✉

Mohamed Khatif Tawaf MOHAMED YUSOF[1]

Muhammad Bazli Faliq MOHD PUAAD[1]

Rozana ZAKARIA[2]

Amin BAKI[3]

[1]MARA Technological University (UiTM), College of Engineering, School of Civil Engineering, Malaysia
[2]University of Technology Malaysia (UTM), Faculty of Engineering, School of Civil Engineering, Malaysia
[3]Envirab Services, Malaysia

Exploring acceptance on benefit of solar farm implementation in Malaysia

Keywords: solar energy, renewable electricity, electricity generation, global warming, climate change, solar photovoltaic

Introduction

Energy is an essential source that is needed for the development and civilization of every country. Energy is used daily to meet human needs for lighting, heating, cooling and transportation. In addition it is also used as input for industrial production (Jeyhun, Shahriyar, Hasan, Serhat & Ridvan, 2020). Despite their contribution to the development of human civilization, fossil fuels are a major contributor to environmental problems, including air pollution, global warming and climate change (Payam & Taheri, 2018). Majority of countries rely on burning fossil fuels to generate

✉shahrul9688@uitm.edu.my

their energy and cause issues such as: supply shortages, supply risk and pricing volatility (Martins, Felgueiras, Smitkova & Caetano, 2019). The adverse effects of climate change are made worse by an over-reliance on fossil fuels, which also raises the pollution levels that permanently harm the atmosphere (Saudi, 2019).

The amount of power produced worldwide has been steadily increasing since 1974. Globally, the average annual growth rate of power output between 2010 and 2018 was 2.5%. 66.3% of the world's gross power production in 2018 came from the production of electricity from combustible fuels such as coal, oil, natural gas, biofuels made of solid biomass and animal products, gas and liquids from biomass, industrial waste, and municipal garbage (U.S. Energy Information Administration [IEA], 2020). The construction sector uses between 20% and 50% of the total energy used globally across many locations. This percentage is higher in highly populated cities, such as Hong Kong, which is more than 60% (Ma & Yu, 2020). As stated by Saidur, Hasanuzzaman, Yogeswaran, Mohammed and Hossain (2010), the construction sector accounts for 36% of CO_2 emissions and 40% of energy consumption in Europe.

Based on research conducted by Ali, Hasanuzzaman, Rahim, Mamun and Obaidellah (2020), due to global temperature that continues to rise, energy consumption in the construction sector increases, especially in terms of air-conditioning. According to earlier studies, the construction industry consumes a significant amount of electricity worldwide, accounting for 40–45% of total electricity consumption in Brazil, the United States of America (USA) and the United Kingdom (Alves, Machado, de Souza & Wilde, 2018). Meanwhile in Asia, it has been recorded that the residential sector came to be the second largest consumer of electricity after the industry and the amount of electricity consumed by the residential sector multiplied from 1971 to 2016 (IEA, 2018). In Southeast Asia, energy consumption is expected to double by 2040, the rise of electricity demand has been among the fastest in the world, increasing by an average of 6% annually. The fastest growing in space cooling usage is one of the contributors to this situation, which is driven by growing incomes and high cooling needs (IEA, 2019).

Many nations continue to generate more power using the traditional power production method of burning fossil fuels. This traditional method releases greenhouse gases and causes air pollution that harms the environment in order to fulfil the growing demand for energy (Hasanuzzaman, Zubir, Ilham & Che, 2016). Burning fossil fuels resulted in the release of dangerous gases, such carbon monoxide, carbon dioxide, nitrogen oxides and sulfur dioxide. A greenhouse gas called carbon dioxide contributes to global warming. Sulfur dioxide can generate acid rain, which harms the aquatic life and plants while also causing respiratory and cardiovascular problems that are more severe in people (EIA, 2022). Various climate change frameworks

have been examined globally over the past few decades aimed at reducing carbon dioxide emissions in order to meet the environmental goals and the socioeconomic needs of the global community (Umar, Ji, Kirikkaleli & Alola, 2021).

People around the world are developing and promoting clean and low carbon energy to respond to the crucial environment issues due to burning fossil fuels to produce energy. Instead, rising prices and limited reserves of fossil energy also worry the industries' players. Therefore, many countries invest in the research and development of renewable energy sources, such as wind energy and solar energy to overcome environmental pollution and the limitation of fossil fuel reserves that lead to the increase in the price of the resources (Payam & Taheri, 2018; Song, Ji, Du & Geng, 2019). Renewable energy is recognized as a very practical means of halting the deterioration of the environment and achieving sustainable development (Kobayashi et al., 2013). Southeast Asia has enormous potential for renewable energy, especially solar energy due to its location to the equator and year-round exposure to solar radiation. However, only about 15% of the region's overall energy needs are now met by renewable energy production. The contribution of solar photovoltaic and wind energy is still minimal despite lowering the costs of the renewable energy technology, while several markets are increasingly putting frameworks in place to better facilitate the deployment of renewable energy (IEA, 2020).

It has been discovered that PV technology is technologically reliable, geographically distributed and has a significant potential for providing sustainable energy sources for producing electricity. Photovoltaic system technology has advanced to become practical, effective and increasingly affordable (Mohammad et al., 2013). Malaysia is perfectly suited to produce solar photovoltaic energy due to its equatorial location, year-round sunshine exposure and high irradiation level. Sunlight is a limitless source of clean energy that can be used to create power. The little moving parts and long lifespan of the technical solar energy equipment, on the other hand, result in the extremely cheap operational expenses for solar panels.

In Malaysia, initiatives to enhance the share of solar and other renewable energy sources in the country's energy mix were established under the National Renewable Energy Policy Action Plan (Sustainable Energy Development Authority Malaysia [SEDA], 2009). This initiative was strengthened in 2015 as part of the Paris Climate Change Conference (COP21) of the United Nations, where the nation committed to reducing its greenhouse gas emissions by up to 40% from their 2005 levels by 2020. The Eleventh Malaysia Plan (2016–2020) set a national goal to achieve an installed capacity of 2,080 MW produced by green energy sources by 2020, up from 243.4 MW in 2014 (Economic Planning Unit, 2015). Solar PV installations produced around 1%, or 227.5 MW, of Malaysia's

total installed electrical capacity in 2016, with the remaining 1% coming from all other green energy sources. Future national goals include the intensification of the development and utilization of renewable energy resources, which include solar PV to meet the target of 31% of the total installed capacity by 2025 (Economic Planning Unit, 2021).

The higher education institution reflects a small town that consists of many buildings, including offices, dwellings, a small hospital, recreation facilities, etc. that characterize a bigger community. College and university campuses consume a huge amount of electricity on a daily basis to run buildings and facilities used by the staff, students and visitors. The higher education institution is a role model to an external community and its activities impact the society, environment and economy. As a result, the large energy demands of these higher education institutions as well as the growing concerns regarding conventional fossil fuel toxic wastes, numerous institutions are struggling to aggressively apply renewable energy projects, such as the PV system in their campuses. Constructing a commercial scale PV system on campus can be a golden opportunity for higher education institutions to highlight their determination toward sustainability. In some interpretations, a PV system on campus gives an impression of forward thinking and being a green institution for the staff, students and visitors (Jo, Ilves, Barth & Leszczynski, 2017). Therefore, the objectives of this study are to determine the financial opportunities of the solar farm implementation as well as to analyze the benefit of the solar farm implementation towards the society and environment.

Material and methods

Data were collected through a questionnaire survey given to the respondents whose job scope directly involved the solar energy. This survey only involved people that have knowledge and experience in solar energy to ensure the accuracy and reliability of the collected data. 34 respondents that took parts in the survey. Most of the respondents in this study were people who work in the government sector, higher education institution, consultant company and contractor company where they were directly involved in solar energy as illustrated in Figure 1.

In this questionnaire survey, majority of the respondents involved were degree holders, who constituted 76% of all respondents. On the other hand, there were three respondents with a master's degree that responded to this survey. In addition, 11% of respondents held a diploma. Respondents who held a certificate were the minority, constituting only 3% of all respondents. Figure 2 illustrates the composition of the

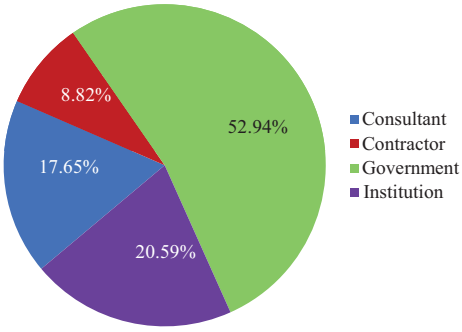

FIGURE 1. Fraction of the respondents based on type of company

Source: own studies.

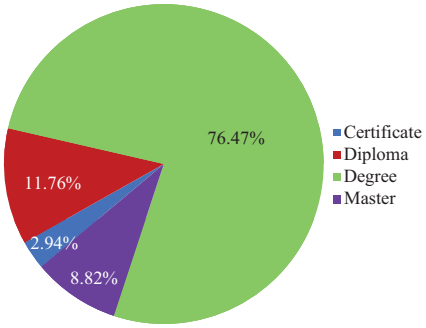

FIGURE 2. Fraction of respondents based on education level

Source: own studies.

respondents based on their education. Based on the education level of the respondents, it was expected that they had sufficient knowledge to give an opinion in this questionnaire survey.

All collected data and information were analyzed by using the average index (*AI*) value to determine the level of agreement of respondents through their feedback answers. The frequency analysis was used in analyzing the frequencies and *AI* value of the respondents relating to the variables in the questionnaires. In order to analyze the data, the average index analysis was used to determine the level of significance of the data. Table 1 shows the average index and level of significance. The average index was calculated based on the equation, as follows:

TABLE 1. Average index and level of importance

Average index (*AI*)	Level of importance or evaluation
$1.00 \leq AI < 1.50$	not important/strongly disagree
$1.50 \leq AI < 2.50$	less important/disagree
$2.50 \leq AI < 3.50$	neutral
$3.50 \leq AI < 4.50$	important/agree
$4.50 \leq AI \leq 5.00$	very important/strongly agree

Source: own studies.

$$average\ index = \frac{\sum \alpha_i x_i}{\sum x}, \tag{1}$$

where: a_i – constant expressing the weight given to i, x_i – frequency of response for i = 1, 2, 3, 4, 5 and illustrated as follows: x_1 – frequency of the response 'strongly disagree' and corresponding to 1; x_2 – frequency of the response 'disagree' and corresponding to 2; x_3 – frequency of the response 'average' and corresponding to 3; x_4 –frequency of the response 'agree' and corresponding to 4; x_5 – frequency of the response 'strongly agree' and corresponding to 5.

Results and discussion

Financial opportunities of solar farm implementation

The benefits of the solar farm implementation in Malaysia are determined through the respondents' perception who were involved in the solar energy industry. The analysis of benefits of the solar farm implementation is presented in a descriptive analysis form as shown in Figure 3. In this research, the agreement level is determined based on the mean score acquired from the respondents' responses. The element is only considered significant when the mean score of the element equals 3.4 or more.

Figure 3 shows the analyzed data from the survey. It was found that long-term financial savings identified the financial opportunities the most because solar energy is free and it is available all year long in Malaysia. What is more, solar farms have less rotating equipment compared to a conventional fossil fuel generator, hence the maintenance cost is lower over the long-term operation. The free and non-depleting energy source was the second most identified financial opportunity. The price of fossil fuels shows the incremental trend over the years due to the growing demand and depletion of resources. It is different for solar farms, it will only need solar energy to generate electricity and there will be no issue regarding the price as it is a free and non-depleting source of energy.

Solar farm implementation will encourage the establishment of more businesses related to solar energy in the country. Solar farms are a new method of generating electricity in Malaysia compared to the fossil fuel electric generator. Therefore, it will create a new demand of business in the solar energy technology and attract foreign direct investment into the country to meet the country's aspiration to implement the solar farms in generating clean electricity. The solar technology company will flourish to meet the country's demand regarding the implementation of solar farms. Based on the conducted survey, the low risk investment and fast installation process obtained the lowest average index value of under 3.5. It is because solar farm technology is still new in Malaysia and there will be a lot of uncertainties associated with the high risk of investment. Many investors are still afraid to make investments and still carefully observe the operation of solar farms in generating electricity in order to get the investment return back. It is believed that once the business and technology of solar farm are mature in Malaysia, the risk will gradually decrease and it will attract many investors who will get involved in solar farms to generate electricity. Over time, expertise and technology in constructing solar farms will keep improving and the installation of solar farms can be accelerated in the future.

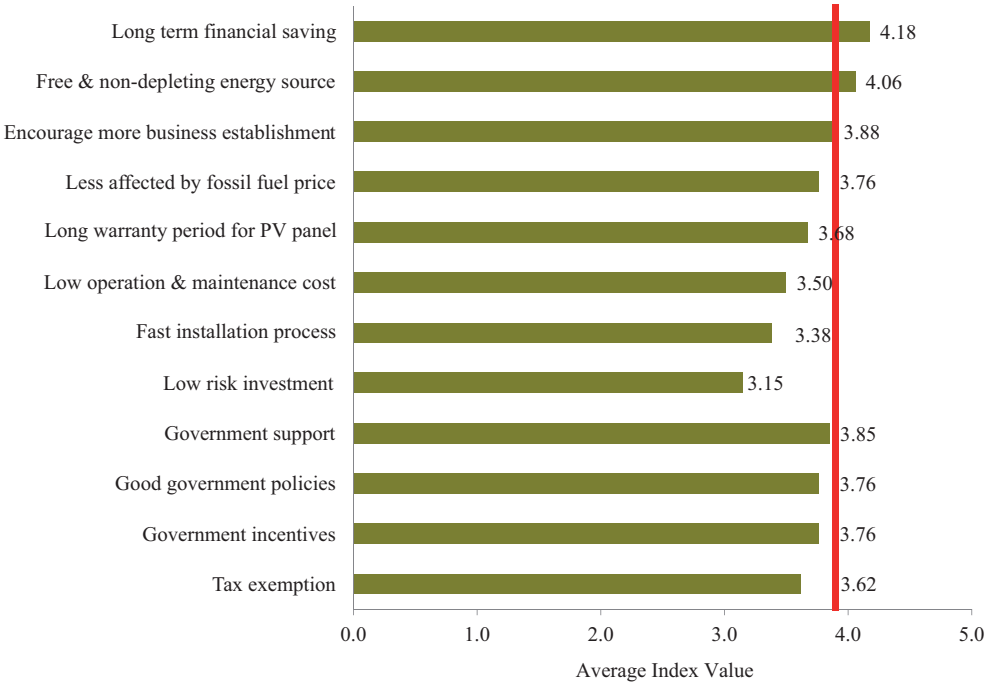

FIGURE 3. Mean score of financial opportunities of solar farm implementation
Source: own studies.

Benefit of solar farm implementation toward society

The survey included five elements being asked for the benefit of the solar farm implementation towards the society. The elements were as follows: less noise during operation, safe operation environment, being a role model to others, creation of job opportunities, and improving the level of health. Based on the analysis of the collected data, the top three elements were: less noise during operation with the highest average index value of 4.24, followed by safe operation environment with the score of 4.15, and then by being a role model to others with a score of 4.15.

Figure 4 shows the benefits of the solar farm implementation towards the social aspect for the society. Conventional fossil fuel power plant produces a high level of noise due to high speed of rotating equipment, such as turbine in generating electricity, which will disrupt the nearby community. However, electricity is generated directly from the solar energy conversion in solar farms by the means of a photovoltaic panel and there will be less rotating equipment that can produce noise, hence no noise issues in the surrounding area. Solar farms also create safe operation environ-

Mohammad, Sh. N., Mohamed Yusof, M. K. T., Mohd Puaad, M. B. F., Zakaria, R., Baki, A. (2023). Exploring acceptance on benefit of solar farm implementation in Malaysia. *Sci. Rev. Eng. Env. Sci.*, *32* (1), 87–98. DOI 10.22630/srees.3899

FIGURE 4. Benefit of solar farm implementation toward social
Source: own studies.

ment where workers are exposed only to limited risks because they will not have to deal with high temperature and high-pressure operations that usually take place in conventional fossil fuel power plants.

Other than that, the implementation of solar farms can also be a role model to others so that more parties will have the confidence to get involved in solar farms as a method to generate electricity. When many parties participate in the solar farm investment to generate electricity, solar energy will become more common to the public and will get accepted in the society. At the same time, locals will draw the benefits through the creation of new jobs that will improve the economy standard of the local community. Furthermore, solar farms will boost the establishment of other supply chain business, where each one will require human capital to support the growth of the solar farm industry. Lastly, solar farms can improve the level of health of the public due to zero carbon emissions because solar farms do not burn any fuel during the operation of generating electricity. In order to generate electricity, solar energy is directly converted into electric power and it does not produce pollution during the operation, hence the health level of people around the solar farm will not be affected.

Benefit of solar farm implementation toward environment

In the survey that was conducted on the benefit of solar farms towards the environment, there were six elements that required feedback from the respondents. The elements were as follows: reduced greenhouse gas (GHG) emissions, being environmentally friendly, clean energy, conservation of natural resources, utilization of brownfield sites, and no massive deforestation. Figure 5 depicts the mean score of benefits of solar farm implementation to the environment. The figure shows that

FIGURE 5. Mean score of environmental benefits of solar farm implementation
Source: own studies.

generally solar farms are more environmentally friendly compared to conventional fossil fuel power plants in generating electricity to fulfil human needs for energy. There are lots of benefits of solar farm implementation to the environment. Reduced GHG emissions are the element that scores the highest with the mean score of 4.53 based on the responses of the respondents.

Firstly, the implementation of solar farms can reduce greenhouse gas (GHG) emissions to the environment because it will not burn any fuels that can produce GHGs, such as carbon monoxide. Secondly, the solar farm implementation is environmentally friendly as it will not pollute water, air and soil of the solar farm site. It has been proven that a PV panel that is used in a solar farm directly changes the solar energy into the electric energy without emitting any emissions during the process. Next, the implementation of solar farms will lead to the generation of clean energy whereby the carbon footprint of the generation of electricity through solar farms is low compared to fossil fuel power plants. Moreover, the use of solar farms to generate electricity can conserve natural resources such as coal, diesel and natural gas, so that it can reduce the dependency on fossil fuels in generating electricity. Furthermore, solar farms can be implemented to utilize brownfield sites where other constructions cannot take place, such as abandoned landfills and factories. Therefore, all brownfield sites in Malaysia can be fully utilized to produce clean energy in order to protect our environment.

However, respondents' feedback on no massive deforestation is not significant with the score of only 3.0, which is less than 3.5. It is because in order to implement solar farms a huge area of land will be required. If the solar farm is to be implemented in the rural area, then deforestation needs to be done to clear the site, so that the solar farm can be constructed. Hence, when it comes to deforestation,

it still needs to be done to construct the solar farm just like any other conventional fossil fuel power plant. Besides other benefits that can be offered by solar farms in generating electricity, the forest will be affected by the construction of solar farm. Therefore, the selection of the site for the construction of the solar farm plays an important role to the environmental protection. The authorities that are involved in decision-making regarding the site selection must consider all factors to balance the benefit of the solar farm and the side impact to the forest.

Conclusions

Solar PV was been introduced decades ago as a solution for clean energy and environment issues. In developing solar farms, huge amount of money is needed for the initial capital cost. Therefore, finances constitute the main criteria that needs to be taken into consideration in a high investment decision. Based on the conducted research, there are numerous financial benefits of solar farm implementation in Malaysia. For example, the investment in solar farms provides long term financial saving as a result of lesser dependency on fossil fuels. Furthermore, solar energy is a free energy source from the sun, and it will allow more businesses related to solar energy to be established in the country in order to meet the demands. Proper implementation of solar farms can enhance the country's role in the PV technology and simultaneously open the opportunities for local talents to be involved in the solar panel technology.

Furthermore, the solar farm implementation gives benefits in the social aspect. For instance, there will be less noise from solar farms because there will be very little rotating equipment in the power plants, thus the solar farm can be installed near the community. The solar farm also offers a safe operation environment to the personnel as explosions will be less likely because the plant generates electricity without burning any fossil fuels. Eventually, there will be no smoke and carbon emissions during the operation of the solar farm in generating electricity because PV panels directly convert solar energy into electric energy and this clean power plant will bring benefits to the human health.

In addition, benefits in environmental conservation are a strong advantage of solar farm implementation. For example, implementation of solar farms in generating electricity helps to reduce GHG emissions and conserve natural sources. Nowadays, environment issue is of a global concern because our world is facing global warming and natural disasters that affect human life. Thus, people believe that solar farm system is a solution to tackle environmental issues and at the same time provide reliable energy for daily activities. By implementing solar farm system in generating energy, Malaysia contributes to protecting the environment by reducing pollution in power plants.

Acknowledgements

This work was technically supported by Universiti Teknology Mara (UiTM) Cawangan Johor Kampus Pasir Gudang.

References

Ali, S. B. M., Hasanuzzaman, M., Rahim, N. A., Mamun, M. A. A. & Obaidellah, U. H. (2021). Analysis of energy consumption and potential energy savings of an institutional building in Malaysia. *Alexandria Engineering Journal*, *60* (1), 805–820.

Alves, T., Machado, L., Souza, R. de & Wilde, P. (2018). Assessing the energy saving potential of an existing high-rise office building stock. *Energy and Buildings*, *173*, 547–561.

Economic Planning Unit, Prime Minister's Department (2015). *Eleventh Malaysia Plan, 2016––2020.* Kuala Lumpur: Economic Planning Unit, Prime Minister's Department.

Economic Planning Unit, Prime Minister's Department (2021). *Twelfth Malaysia Plan, 2021––2025.* Kuala Lumpur: Economic Planning Unit, Prime Minister's Department.

Hasanuzzaman, M., Zubir, U., Ilham, N. & Che, H. (2016). Global electricity demand, generation, grid system, and renewable energy polices: a review. *Wiley Interdisciplinary Reviews: Energy and Environment*, *6* (3), 222.

Jeyhun, I. M., Shahriyar, M., Hasan, D., Serhat, Y. & Ridvan, A. (2020). Elasticity analysis of fossil energy sources for sustainable economies: A case of gasoline consumption in Turkey. *Energies*, *13* (3), 731.

Jo, J., Ilves, K., Barth, T. & Leszczynski, E. (2017). Implementation of a large-scale solar photovoltaic system at a higher education institution in Illinois, USA. *AIMS Energy*, *5* (1), 54–62.

Kobayashi, T., Kanematsu, H., Hashimoto, R., Morisato, K., Ohashi, N., Yamasaki, H. & Takamiya, S. (2013). Study on environment and energy using belonging materials. *International Journal of Sustainable Development & World Policy*, *2* (4), 50–58.

Ma, Y. X. & Yu, C. (2020). Impact of meteorological factors on high-rise office building energy consumption in Hong Kong: from a spatiotemporal perspective. *Energy and Buildings*, *228*, 110468.

Martins, F., Felgueiras, C., Smitkova, M. & Caetano, N. (2019). Analysis of fossil fuel energy consumption and environmental impacts in European countries. *Energies*, *12* (6), 964.

Mohammad, S., Zakaria, R., Omar, W., Abd Majid, M. Z., Saleh, A. L., Mustaffar, M., Zin, R. M. & Jainudin, N. (2013). Potential of solar farm development at UTM campus for generating green energy. *Applied Mechanics and Materials*, *479–480*, 553–558.

Payam, F. & Taheri, A. (2018). Challenge of fossil energy and importance of investment in clean energy in Iran. *Journal of Energy Management and Technology*, *2* (1), 1–8.

Saidur, R., Hasanuzzaman, M., Yogeswaran, S., Mohammad, H. A. & Hossain, M. S. (2010). An end-use energy analysis in a Malaysian Public Hospital. *Energy*, *35* (12), 4780–4785.

Saudi, M. H. M. (2019). The role of renewable, non-renewable energy consumption and technology innovation in testing Environmental Kuznets Curve in Malaysia. *International Journal of Energy Economics and Policy*, *9* (1), 299–307.

Song, Y., Ji, Q., Du, Y. J., & Geng, J. B. (2019). The dynamic dependence of fossil energy, investor sentiment and renewable energy stock markets. *Energy Economics*, *84*, 104564.

Sustainable Energy Development Authority Malaysia [SEDA] (2009). *National renewable energy policy and action plan.* Kuala Lumpur: SEDA.

Umar, M., Ji, X., Kirikkaleli, D. & Alola, A. (2021). The imperativeness of environmental quality in the United States transportation sector amidst biomass-fossil energy consumption and growth. *Journal of Cleaner Production*, *285*, 124863.

U.S. Energy Information Administration [EIA] (2018). *World energy balances: overview*. Retrieved from: https://webstore.iea.org/world-energy-balances-2018-overview [accessed 23.08.2022].

U.S. Energy Information Administration [EIA] (2019). *Southeast Asia Energy Outlook 2019*. Retrieved from: https://www.iea.org/reports/southeast-asia-energy-outlook-2019 [accessed 23.08.2022].

U.S. Energy Information Administration [EIA] (2020). *Electricity information: overview*. Retrieved from: https://www.iea.org/reports/electricity-information-overview [accessed 23.08.2022].

U.S. Energy Information Administration [EIA] (2022). *Electricity explained*. Retrieved from: https://www.eia.gov/energyexplained/electricity/electricity-and-the-environment.php [accessed 23.08.2022].

Summary

Exploring acceptance on benefit of solar farm implementation in Malaysia. Implementation of solar farms to generate electricity is still low in Malaysia, where only 1%, or 227.5 MW of the total installed electrical capacity in Malaysia was produced from solar PV installations in 2016. Renewable energies, e.g. solar energy, have been adopted in many countries to generate electricity as a response to global environment issues. The aim of this study is to determine financial opportunities and benefits of solar farm implementation towards the society and the environment. Data were acquired through a literature review and questionnaire survey that was conducted among the respondents that are directly involved in the solar energy. Long-term financial savings constitute the most identified financial opportunities for the implementation of solar farms in generating clean electricity. Implementation of solar farms will encourage more businesses related to solar energy to be established in the country and will lead to new business opportunities. Solar farms are far better than conventional fossil fuel power plants in terms of the environmental effect and also reduce the health effects on the society during the electric generating process.