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Marketability Potential of Innovative Outdoor Air Filter to Improve Air Quality at the Construction Site

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Abstract

Malaysia is one of the emerging and developing countries which is still undergoing rapid economic development. The construction industry is the most active sector affecting the country's economic growth. Industrialized Building System (IBS) is getting popular in construction industries nowadays as it has many advantages. However, this system may contribute to the air pollution catastrophe in Malaysia because of the extensive use of cranes and trucks, which use internal combustion that produces enormous pollutants to the atmosphere. This paper aims to study the innovative outdoor air filter's marketability potential to improve the construction site's air quality. A simulation method using SketchUp Software is used to visualise the innovative outdoor air filter as well as the application of the outdoor air filter machine. Online questionnaires are also distributed to contractors around the Klang Valley to evaluate the marketability of the innovative product. The descriptive analysis using percentages and means is used to analyse the questionnaire survey result. The results found that the respondents agreed that the innovative outdoor air filter could potentially be a commercialised construction industry, specifically at the construction site. This innovative outdoor air filter machine has the potential to provide cleaner air and a healthier environment at the construction site. This innovative product may help the construction industry to reduce the air pollution issues at the construction site.

Keywords: Marketability, Innovation, Outdoor Air Filter, Air Quality, Construction Site

Introduction

Air pollution is one of the leading global issues that should be focused on as it causes seven million casualties annually (Guterres, 2019). Many sources lead to air pollution, such as fossil fuel burning, chemical processes, agriculture, and even natural phenomena (EEA, 2017). Among all the factors that lead to increases in air pollutants produced in the air, fossil fuel

burning in the transportation sector plays a vital role in this global concern. Recently, the transportation sector, especially that related to construction, has experienced a considerable improvement in many air pollutants released (EEA, 2019). Nevertheless, transportation, including heavy-duty cranes and trucks, is still responsible for the health burden caused by the rising of fine particulate matter such as carbon monoxide, ozone and nitrogen dioxide (Anenberg et al., 2019).

Air pollution is also one of the pollution issues in Malaysia (Wen & Mohd, 2016). Ahmed and Arocho (2019) pointed out that the construction industry is one of the factors leading to this issue, as this sector is the primary source of high pollutants in the atmosphere. Unfortunately, there is a limited study on outdoor air filters (Newsd, 2016). The only outdoor air filter, Smog Free Tower, was installed in Beijing a few years ago. However, the previous study evaluating the product's performance and marketing properties is scanty. Therefore, the objectives of this paper are to propose an innovative product to cater for the issue of air pollution at the construction site and to evaluate the innovation product's marketability potential.

Literature Review

a. Overview of the Air Pollution Issues

World Health Organization (2016) stated that air pollution kills an estimated seven million people yearly. The data shows that 9 out of 10 people breathe air containing high levels of pollutants that affect their health. The smog hanging over the cities and that comes from the factories and machinery are the leading cause of air pollution. Many effects come from ambient and household air pollution, including heart disease, strokes, premature deaths, chronic obstructive pulmonary disease and lung cancer (World Health Organization, 2016).

It is well known that air pollution can be harmful to human health. Air pollution can contain a mixture of solid particles, liquid droplets and gases from various sources. One of the primary sources is the construction industry which emits various dangerous gases into the atmosphere. Based on Losacco and Perillo (2018), exposure to air pollution may cause a wide range of health effects. These vary from mild symptoms such as irritation of the eyes, nose and throat to more severe conditions like respiratory and cardiovascular diseases. The common source of outdoor air pollution is emissions caused by combustion processes from motor vehicles, solid fuel burning and industry.

Air pollution damages the natural environment with pollutants and harmful particulates in the air. Air pollution mostly happens in urban areas, with many construction activities such as building renovation, infrastructure construction and the various types of vehicles which use fuel to generate the engine. Urban air pollution is a serious problem worldwide, as stated by (Sivertsen and Bartonova, 2012). The gravity of the urban air pollution problem is primarily attributed to the complex and multi-sectoral nature of everyday air polluting activities.

Air pollution is dangerous for human health, which causes respiratory and other diseases that may lead to fatal. Air pollution impacts humans and can cause various environmental effects, including acid rain, eutrophication, haze, ozone depletion and global climate change. Ivaskova et al (2015) pointed out that air pollution also may damage civil engineering structures like bridges, historic buildings and monuments. In addition, the increase in population and the quest for development, such as the built environment, has resulted in ozone layer depletion, global warming, resource depletion and ecosystem destruction, as stated by Ametepey and (Ansah, 2015). This scenario has put the built environment and the construction industry under the spotlight since its activities significantly impact the environment.

b. The Importance of Clean Air

Good air quality is vital for every living thing on earth. Richie and Roser (2019) asserted that the primary air pollution problem in developed and rapidly industrialising countries has typically been high levels of smoke and sulphur dioxide. The combustion of sulphur-containing fossil fuels, such as coal, used for domestic and industrial purposes is also one of the problems associated with air pollution. In addition, particulate matter is one of the significant distributors of air pollution from the construction process. *Particulate matter* is a microscopic particle that can be taken deep into the lungs and pass directly into the bloodstream, which can cause health problems, including hard to breathe.

The Ministry of Works Malaysia has proactively developed Construction Industry Transformation Programme (CITP) through the Construction Industry Development Board (CIDB). The primary function of CITP is to empower and strengthen the construction industry to the next level following four strategic thrusts, including environmental sustainability being incorporated in the design, construction and subsequent maintenance of buildings and infrastructure and also to improve the overall quality, safety and professionalism of the industry (CIDB, 2015). Grigorjev (2018) stated that eco-innovation is essential in overcoming air quality problems. Formerly, the production of outdoor filters built at the construction site will help improve air quality at the construction sites and sustain the environment.

Construction Industry Transformation Programme (CITP) stated that Malaysia today has a prevalence of inefficient construction practices that risk harming the environment (CIDB, 2015). CITP aspires to be a model for the emerging world by having environmentally sustainable construction in Malaysia. This programme aims to reduce the emission of hazardous gases, mainly from construction sites, such as carbon dioxide, which may be achieved by using air filters to reduce the pollutants. Besides CITP, Green Technology Master Plan Malaysia (GTMP) 2017 to 2030 also highlighted the aspect of technology advancement and innovation related to this study (Mahat et al., 2019). Technology advancement and innovation play a crucial role in developing knowledge and an innovation-based economy. Malaysia is now focusing on developing a low-carbon economy and intensifying its low-carbon technology.

c. Previous Research Related to Air Pollution Conducted Worldwide

One of the causes that lead to severe air pollution comes from fuel combustion. Norman et al (2009) stated that critical factors affecting a vehicle's fuel economy on the prescribed driving schedules are the vehicle design, vehicle mass, rolling resistance, engine and transmission efficiency. Fuel economy can also be significantly affected by driver behaviour. Moreover, hard acceleration, idling and carrying unnecessary weight can negatively affect the fuel economy and produce more contaminants in the air. Proper filters in the engine, also with proper maintenance, can help the vehicle to perform as it was designated. A clogged filter affects a vehicle's acceleration and impacts a carburetted engine due to a choking effect in which the engine operates at more prosperous combustion conditions.

Ahmed and Arocho (2019) stated that environmental deterioration has captured the world's attention and has been one of the most discussed subjects globally. Eventually, the world was posited in a crucial environmental catastrophe by construction activities that affect the environment throughout the life cycle of development. These impacts occur from initial work

on-site through the construction and operational periods to the final demolition of a building. Furthermore, construction project development potentially contributes to economic and social development and enhances both the standard of living and the quality of life (Ametepey & Ansah, 2015). Ametepey and Ansah (2015) also asserted that the second largest sector contributing to the Ghanaian social and economic sector is the construction sector. However, it is negatively active in environmental contribution. Moreover, the construction industry is one of the largest exploiters of renewable and non-renewable natural resources. It relies heavily on the natural environment to supply raw materials such as timber, sand and aggregates for the building process. According to Worldwatch Institute (2013), the construction sector especially building construction, consumes 40% of the world's raw stones, gravel and sand plus 25% of virgin wood annually.

Air pollution is a severe problem in many parts of the world. Over decades, air pollution has been one of the most significant issues in South East Asia, mainly affecting Malaysia and Indonesia due to urbanisation and rapid growth of the industrial sector, as highlighted by (Wen and Mohd, 2016). Furthermore, the increase in traffic volume and the expansion in the petroleum and diesel sector for vehicles move also include air pollution. Modern technologies have to speed up construction by using heavy-duty trucks and cranes. However, it leads to rapid air pollution.

d. Problems Related to Existed Air Filter

Based on the literature, only one existing outdoor air filter in Beijing is still on trial (Cyranoski, 2018). The air filter is only 23 feet (23 ft) tall, which can eliminate 70 per cent of the impurities in the air from the size of a football stadium. The outdoor air filter also uses 1400 watts (1400 W) per day which may achieve 42 000 watts (42 000 W) per month. In this innovation project, the outdoor air filter will use a solar panel system as the electric source for energy sustain.

Various machines can filter the air, including air ionisers, air conditioners and air filters. The urbanisation process increases the population density in cities and consequently leads to severe indoor air pollution, which has been proved by (Liu et al., 2017). As a result of these trends, the issue of a sustainable and healthy indoor environment has caught up many attentions and various air filtration techniques to optimise indoor air quality. Air filtration can remove and eliminate air pollutants and effectively alleviate the deterioration of indoor air quality. However, many air filters use tremendous energy to operate the machines. Energy consumption may defect the depletion of non-renewable energy. Air is not only vital for any life form on earth but also crucial for today's state of automotive engines. Janarthanan et al (2015) pointed out that an average heavy-duty truck engine requires 13 000 to 20 000 litres of air to burn just one litre of fuel. Consequently, the air will be polluted with all kinds of contaminants such as fumes, dust, smog and other particles. The truck's engine can diminish the purity of air and may lead to engine damage. However, the air filter only has one opportunity to filter the contaminant out of the intake air. An innovative air filter with a better air induction and maintenance system may solve this problem.

e. Application of Solar Energy

Intense research has been focused on developing solar energy conversion devices in the past to invent energy conversion devices that may satisfy future energy needs. Dye-sensitised solar cells have attracted much research due to their prospected potential for fabricating low-cost

solar energy conversion devices with good efficiency (Bandara et al., 2014). In addition, dye-sensitised cells generally have a lower efficiency than silicon-based solar cells. However, in low intensity and diffusion of light, the dye-sensitised efficiency is boosted compared to the solar cells in full sunlight. It is vital to sustain the environment by applying solar energy instead of non-renewable energy and keeping a healthy future by decreasing carbon dioxide emissions.

Methodology

Methodology

The methodology to propose the innovation product is visualisation action using simulation. In contrast, the product's marketability potential is measured by an online questionnaire survey of the potential user of the product.

a. Simulation

Simulation is one of the best methods to visualise the idea as it gives the east an understanding of the concept and the design for this project. The simulation process for this project is divided into two stages, i.e., the assembling process of the prototype and the application of the products. A SketchUp software is used for the simulation

b. Online Survey

Online questionnaire marketability surveys are popular nowadays as they allow the surveyor to distribute the survey form. For this project, Google online form has been used to perform this questionnaire. The questionnaires were sent to the construction workers around Klang Valley in five sections starting with section A until section E. There are 339 IBS concrete construction companies in the Klang Valley (CIDB, 2018). However, the online survey has been distributed to 34 companies representing 10% of the population, with a 16% margin of error using the Raosoft Sample Size Calculator (Raosoft.com, 2004). The descriptive analysis using percentages and means is used to analyse the questionnaire survey result.

Findings and Discussion

a. Propose an Innovative Outdoor Air filter as Innovation for Construction Site

This study proposes an outdoor air filter as an innovation to cater for the problem of air pollution at the construction site. The proposed outdoor air filter is a straightforward machine designed to filtrate and eliminate pollutants flying in the atmosphere, especially at the construction site. Since the innovation product’s primary function is to decrease the concentration of the pollutants, the machine’s position needs to be posited at the highest concentration of pollutants, such as at the installation place and storing raw materials, which may produce debris and smoke. The debris and smoke containing micro-particles are denser than the clean air. This scenario makes the pollutants stay at the bottom of the atmosphere while less dense air stays on top of the atmosphere. The outdoor air filter will penetrate air from the body at a 360-degree angle (360^0) and then flow out the cleaner air from the fan on top of the machine. The filtration process of the machine is visualised for easier understanding.

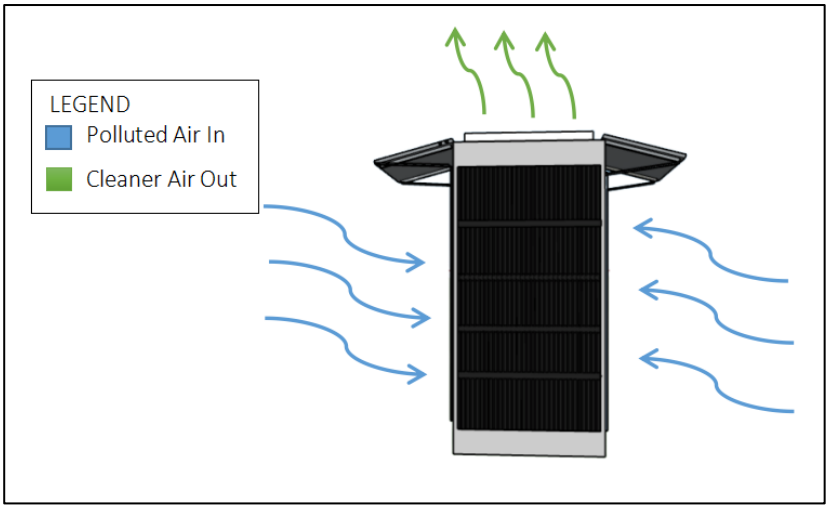


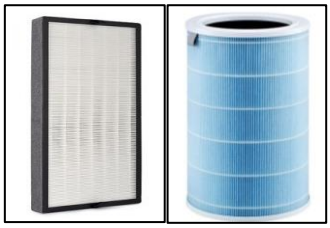
Figure 1: The filtration process of the Outdoor Air filter

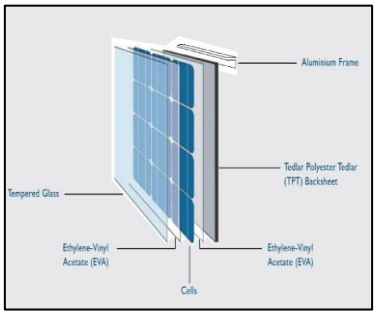
(i) Materials and Components Proposed for Innovative Outdoor Air Filter

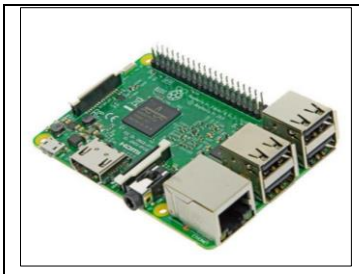
Properties and features of the material used for the innovative product are vital to ensure the safety and durability of the product. In addition, the quality of the product also depends on the materials used. Table 1 describes the materials and components of the proposed innovative outdoor air filter.

Table 1

The description of the materials and component of the proposed innovative outdoor air filter.

Material	**Description**
Aluminium Metal	Aluminium metal has been proposed to be used as the body part of the product. It will hold the standing filter and the fan blade with the solar panel as a whole. Aluminium has a lightweight characteristic that helps reduce the weight of the innovative product. The lightweight material is suitable for the product as it may ease the product for transportation and installation.
Filter  Source: Geekbuying.com; estore.pensonic.com	There are two types of filters used for this innovative product. The flat surface filter is usually used in indoor air filters and air purifiers. The materials used for this filter are polyester impingement air filter media, which have high strength and durability that can trap a high volume of contaminants within the fibre. The polyester fibre does not flake, shed or have sharp edges. The cylinder shape is located inside the body of the machine. This filter is made of foam air filter materials, with many layers to discrete the contaminants and pollutants that still penetrate the machine. This filter also contains activated carbon that can cause discrete odour from filtration.
Fan Blade	The fan blade is one of the vital components of the innovation idea. It is the most crucial element to successfully function the machine as it conquers the performance of the whole product. The material proposed

 Source: www.globalindustrial.com	for the fan blade is aluminium as it has lightweight and suitable for the high location. The fan uses a direct current (DC) motor connected to the solar panel as it directly uses the sun as the power source. This help in consuming less than 70% power compare to a typical fan.
Solar Panel  **Anatomy of solar panel** Source: 7efe.com	The solar panel is made of a combination of two elements which are silicon and silver. For this innovative outdoor air filter, a monocrystalline silicon solar panel has been proposed to be used. The panels are grouped in 60-cell panels connected by busbars. The busbar ribbon is made of aluminium and wires the solar cells together to create higher voltages. The crystal framework in monocrystalline produces a perfect blue colour and has the highest purity, and efficiency levels compare to the other type of solar panels. In addition, the solar panels are surrounded by aluminium frames, adding strength to the panel and protecting the edge of the glass.
Robotic Arm  Source: https://composite-china.com	Four (4) robotic arms are installed to move the solar panel on top of the air filter machine. The robotic arm is connected to the stepper motor and raspberry pi for distance control. The robotic arms are made of aluminium metal with ultra-high modulus to prevent rust and corrosion. It is also strong enough to hold the solar panel together with its durable capability. The robotic arms function to move the solar panel to form a pitched roof when the rain comes in a 45-degree (45°) lay-up orientation. In addition, robotic arms only move in two directions, which are perpendicular to the machine's body, also at an acute angle.
Stepper Motor  Source: https://images.app.goo.gl	A stepper motor is installed between the solar panels and the roof on top of the machine. A stepper motor is a brushless direct current (DC) electric motor that divides a full rotation into several equal steps. The motor is connected to the raspberry pi to be controlled from the operator's device. Torque reading and the speed can be adjusted from the devices to ensure the machine's safety. In addition, all motors located on top of the machines are connected for better adjustment and to prevent malfunction.
Raspberry Pi	Raspberry pi is a series of small single-board computers that act as a programming element for this innovation project. It helps to connect and memorize the system programmed in this innovative product. The code

 Source: https://image.app.goo.gl	programmed in the system using raspberry pi to control the machine only by using a computer or any device anywhere. This element enables the operator to control the movement and the machine's performance anytime. Besides the stepper motors and fan blades' movement, the emergency signals are also connected to the system for awareness of the machine's condition.

(ii)Visualisation of Innovative Outdoor Air Filter

The proposed outdoor air filter innovation components consist of the fan blade, solar panel, body and filter. The innovation idea has a simple concept and design as it may also be used outside the construction site to decrease the number of air pollution cases. However, the innovation idea focuses on the IBS industry, posited as one of the most significant contributors to air pollutants producers (Tokmechi, 2011). A sketch from Sketchup software was used to visualize a better product image. Figure 2 shows the perspective views and labels of the innovative outdoor air filter machine.

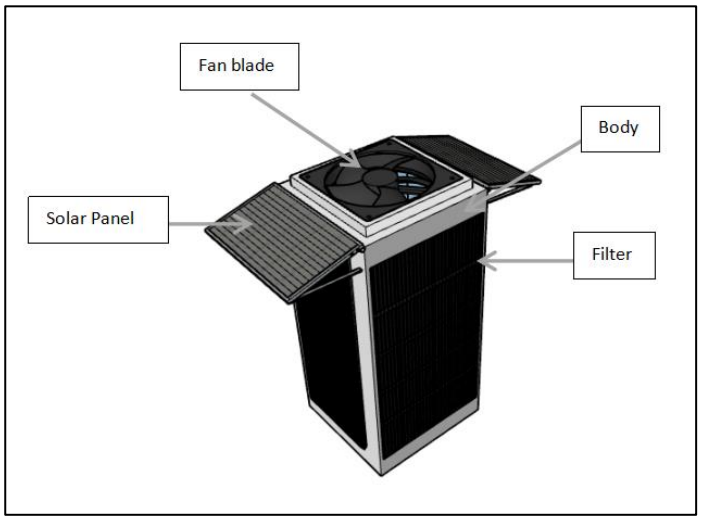


***Figure 2*: Perspective view of the innovative outdoor air filter**

(iii) Proposed Dimension of the Outdoor Air Filter

The basic shape of this product is a cuboid. The cuboid is surrounded by a rectangular filter, which traps more prominent pollutants and dust from getting inside the body., The fan blade and solar panels are located on top of the machine. The body size is 1.25 meters (1.25 m) per side and leaves enough space for the cylindrical filter inside, as shown in Figure 3. The fan frame has a length of 0.9 meters (0.9 m), while the solar panel has 0.75 meters (0.75 m) on the side. Most importantly, the height of the whole machine is 3 meters (3 m), which is quite significant for an air filter. This dimension will help in increasing the surface area of the filtration process.

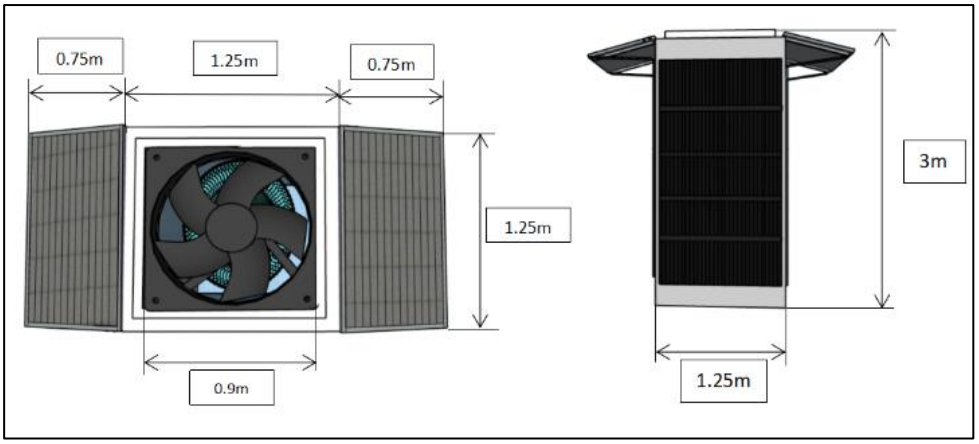


Figure 3: Dimension of the proposed innovative outdoor air filter.

b. Performance of the Innovative Outdoor Air Filter

As mentioned earlier, the outdoor air filter must be installed at the highest number of pollutants in the atmosphere. It is because the innovative product can help reduce the pollutant concentration at the construction site. The innovative product's performance depends on the fan blade's workability and the efficiency of the filters installed. The outdoor air filter machine is enormous and can reach 3 meters (3 m) tall. The size of the fan blade is also huge to perform well. The fan blade can perform 560 rounds per minute (560 RPM), producing 10 200 air flow cubic feet per minute (10 200 CFM). The most remarkable thing about this innovative product is that the machine can be used ideally outside of any building. In addition, it has 360° degrees of filtration to absorb or suck the air into the product. It only used 650 Walt (650 W) electricity from the solar panel as it uses a solar energy source. Last but not least, the area that the innovation product can cover is 15 meters square (15 m2) to undergo the filtration process. The performance of the innovative product is tabulated in Table 2 for better understanding.

Table 2
The performance of the Innovation Product

Element	**Description**
Degree of Filtration	360°
Air flow cubic feet per minute (CFM high)	10 200 CFM
Power use	650 W
Round per minute	560 RPM
Maximum Ambient Temperature	45℃
Cover area	15 m^2
Maximum weight	145 kg
Sound Frequency	60 Hz
Voltage use	120 V
Motor type	Open
Blade quantity	4
Each solar panel rated power	330W
Efficiency of solar panels	40%

c. Safety Features

Safety can be defined as the condition of being protected from the hazard or unlikely to cause danger, risk or injury (Oxford Dictionary, 2020). In this innovation project, a few safety features have been proposed to secure the safety of the machine operation. The safety features of the innovative outdoor air filter include an emergency stop button, sound absorber, anti-rust metal, self-cleansing filters and water residue tubes. All of the safety features have an essential role in the innovative product. Table 3 demonstrates the safety features of the innovative outdoor air filter.

Table 3
Safety features of the innovative outdoor air filter.

Safety Features	Description
Emergency Stop Button	Accidents happen unexpectedly. Every machine created must have a stop emergency button which comply with Occupational Safety and Health Act (OSHA) standards like IEC 60204-1 based on (IEC-International Electrotechnical Commission, 2016). It is accessible to the operator as the button located only at 1 meter (1 m) from the ground. In this innovation project, there will be a signal transfer to the operator or the construction workers when the button has been pushed. The machine will automatically stop when the emergency button is pushed in no time. This button function to prevent any unnecessarily accident to the workers yet the environment. In fact, an emergency stop push button is a fail-safe control switch that provides both safety for the machine as well as the machine operator.
Sound Absorbent	When the fan blade is circulating, it may be produced uncomfortable sound to the surrounding. The large engine moving the fan blades generate vibrations which transfer into the metal structure of the machine and cause them to vibrate. The vibration migrates as structure-borne sound through the machine and emitted to the environment then produce noise. Fortunately, the motor for the rotor blades can be insulated with suitable sound absorbers. It can reduce the noise pollution that are produce by the circulating blades.
Anti-rust Metal	Rusting metal may be dangerous to the living things. The metal can decay and produced airborne contaminants as the metal undergo chemical reaction. The particulate matter such as sulfur dioxide may harm humans' respiratory system. As an addition, rusting metal also can defect the strength and shorten the life span of the metal. Therefore, the body and other features of the innovation outdoor air filter are using aluminium metal to prevent rust and corrosion. It is safe for an outdoor application to both environment and humans.
Self-Cleansing Filter	Huge air filter may be hard to be cleaned. Nonetheless, the filters installed in the innovation product have self-cleansing characteristic which can be cleaned by the rain water flow. When the rain comes, the rain water will flow between the filters and

	secreted the debris and dust yet flow to the ground. This characteristic is helping to ease the real cleansing process every months. In addition, it also helps to ensure the performance of the innovation product as it preventing the filters from clogged and need to work harder from sucking the air. On the other hand, unclogged filters also maintaining the energy efficient as well as protect the internal components of the innovation product. So, this innovation product is essential to sustain the energy
Water Residue Tube	As mentioned, the solar panels will form a pitch roof when it is pouring at the construction site. However, some of the rain water still can enter the innovation product from particular angles. The rain water need to be secreted from the innovation product to prevent water stagnant. To conquer this problem, a water residue tube is install inside of the innovation product to flow out the residue water which entered the innovation product.

d. Application of the Innovative Outdoor Air Filter

The product is proposed to eliminate the contaminant in the atmosphere during construction activities. This innovative product may help reduce the concentration of pollutants at the construction site. Even though Industrialized Building System is an environmentally friendly construction system, the method still releases contaminant air by excessively using cranes and trucks. The production process of raw materials also produces an enormous amount of dust and debris. Installing the innovative product at the construction site may help filtrate the polluted air yet decrease the number of pollutants in the atmosphere. The application of the innovative product is visualized in Figure 4. The contaminants air being suck into the air filter, with the help of a huge fan placed on top of the machine. Then, the pre-filter will filtrate the more significant pollutants such as dust and debris, then the airflow through the carbon filter, which only penetrates cleaner air. In addition, the carbon filter also functioned to remove odour and trap excessive pollutants inside the pore structure. After that, the cleaner air flows from the air filter machine. The primary source of energy for this innovative outdoor air filter is a solar panel system. This system generates direct current electricity by using Plate voltaic cells from sun rays to operate the machine.

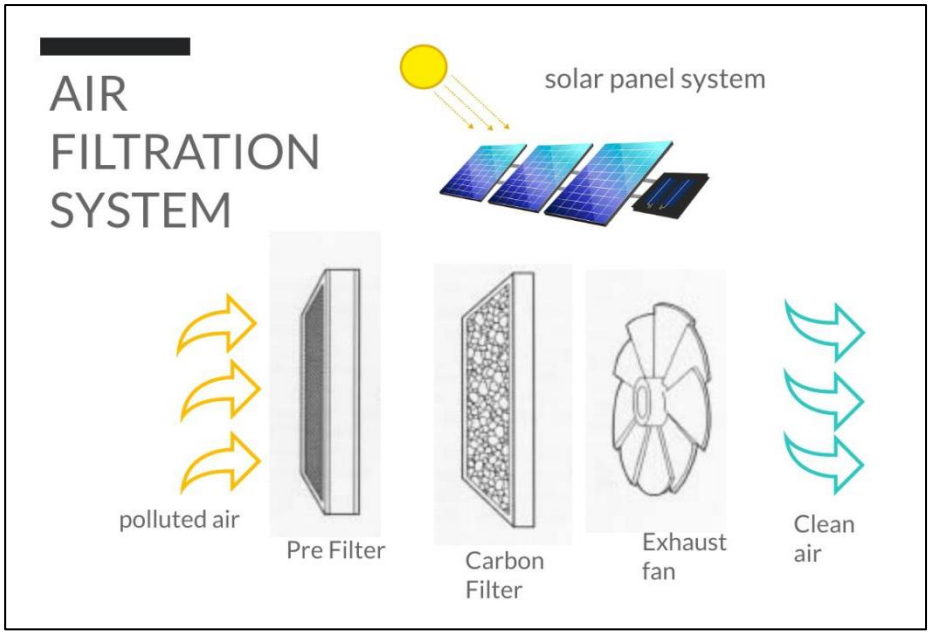


Figure 4: Application of the innovative outdoor air filter.

In this innovation idea, four robotics arms with a synchronized system have been proposed to be installed in the innovation project. The robotics arms hold the solar panel with the air filter machine to function in every type of weather. The robotic arms are programmed to lift the solar panel when it rains using a coding method connected with the raspberry pi. The solar panels are lifted and making a pitched roof base design to reduce the number of rains getting into the machine, as shown in Figure 5. The excess rainwater that gets into the machine helps self-cleaning the filter, both the pre-filter and the carbon filter. In addition, the construction process usually stops when it is raining so the machine can undergo self-cleaning while the construction is paused. The fan blade on top of the machine is also being stopped automatically to prevent an electric shock drowning.

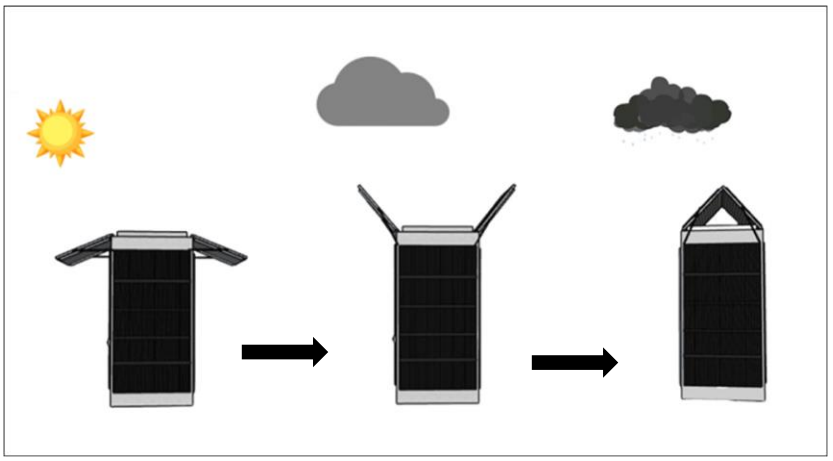


Figure 5: Operation of the innovation product

e. Marketability of the Innovation Product

An online survey using Google Forms has been created to evaluate the marketing potential for the innovative product. The online survey was distributed limited to the construction workers in Klang Valley to gain sufficient data. 34 out of 339 companies have participated in

the survey, representing 10% of the population, with a 16% margin of error (Raosoft.com, 2004). From 34 companies, only 28 respondents from different companies gave back their responses. It shows that only 82.3% of the respondents are giving their answers. The survey comprises contractor(46%), site engineer (11%), site manager (39%) and safety officer (4%).

i. Air Pollution Issues at the Construction Site

In order to identify the air pollution issue, the respondents were asked to answer their site condition based on their self-observation. From the survey, 86% of the respondents agreed that the construction site's air condition is polluted, while only 14% claimed that the air is expected. Hence, the respondents have also been asked about the comfortableness working at their chosen air condition, sources of air pollution at the construction site and awareness of air pollution hazards for human health. The result shows that only 35.7% of the respondents are not comfortable working at the current on-site air condition. The finding also revealed that only 21.4% of the respondents had no pollutants at the construction site. 100% of the respondents were aware of the risk of air pollution to their health. The summary of findings is tabulated in Table 4.

Table 4
Summary of finding from questionnaire survey related above questions.

Questions	**Yes**	**No**
Do you comfortable working on-site with the mentioned air condition?	64.3	35.7
Is there any source that produce pollutants at the site?	78.6	35.7
Do you aware that polluted air may harm your health?	100	0

ii. Proposed Innovation Idea

The respondents were asked for opinions on the proposed innovation idea of the outdoor air filter machine. The respondents' opinions were asked using a 5-point Likert scale. It started with strongly disagree, disagree, neutral, agree and strongly agree. The respondents needed to choose the most relatable scale to answer the questions.

Table 5 shows the respondent's opinions on the innovation idea. Overall, most of the respondents are likely to accept and like the proposed innovation idea. More than half of the respondents agree that the design and idea concept of the innovative product is unique and rare. They also believe that the innovation idea is practical and logical. All of the respondents understand the simple application of the innovative product. Plus, 100% of the respondents agree that the innovative product will benefit the environment and humans.

Table 1
Respondent's opinions on the innovation idea

Opinions	**Number of Respondents**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The idea concept of the innovation idea is very unique.	0	2	5	13	8
The design of the proposed innovation idea is new and rare.	0	1	4	9	14

The concept of the proposed innovation idea is practical.	0	0	5	14	9
The application of the innovation idea is easy to understand.	0	0	1	10	17
The proposed performance is logical and acceptable.	0	0	3	12	13
The proposed innovation idea can benefit the environment and human life.	0	0	4	11	13

iii. Marketing Potential of Outdoor Air Filter

85.71% of the respondents believed that the innovative product has high marketing potential. Based on Table 6, two out of 28 respondents did not think the innovative product has value in the marketplace. However, three respondents have a neutral feeling about the innovation being placed on the market. Moreover, the rest of the respondents agree that innovative product is valuable in the marketplace.

Table 2
The value of the innovation product on market

Opinions	**Number of Respondents**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The innovation idea has value in the market place	0	2	3	10	14

Conclusion

Air pollution issues must be kept an eye on as they may infect living things and the environment. Air pollution catastrophe may affect the skin and respiratory system of humans and animals. An innovative air filter should be installed in highly concentrated pollutant areas to decrease the number of pollutants in the atmosphere. Based on the findings, the construction site is one of the areas with high concentrations of pollutants, which is suitable for installing the innovative outdoor air filter. The innovative outdoor air filters can reduce the construction site's air pollution. However, the product needs to be improved from the mechanism and electrical system perspective. The maintenance operation of the machine also needs to be studied for better workability and performance. The outdoor machine should be suitable for every weather as it is exposed to the atmosphere. In the aspect of the machine's performance, the power of the fan blade needs to be strong enough to suck surrounding air around the innovative product. Nonetheless, the proposed innovation product can practically be marketable in the industry as it may function perfectly. It may reduce the concentration of the pollutants in the air and lower the risk of humans getting any disease. In a nutshell, the innovative product has been proposed in Industrialized Building System to drop the number of air pollutants in the atmosphere as it may harm human health.

Contributions of Research

Innovation is vital to improving something of an existing product that may benefit others. This innovative outdoor air filter can help reduce pollutants in the surrounding areas, especially the construction site. It will benefit the workers and the environment by creating cleaner air for breathing and working. Besides, this product uses environmentally friendly materials and anti-rust components to achieve green product standards. The use of solar energy systems to operate the product in a sustainable environment also helps to reduce carbon footprint by preventing the use of direct electricity concept and reducing global warming.

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