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**“DESIGN, FABRICATION, AND PERFORMANCE ANALYSIS
OF A SOLAR POWERED AIR PURIFIER”**

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LETTER OF TRANSMITTAL

September, 2023

To

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Subject: Submission of Project Rrport

Dear Sir,

We are pleased to submit the project report on “design, fabrication, and performance analysis of a solar powered air purifier”.It was a great pleasure to work on such an impotant topic. This project has been done as per instruction of your supervision and according to the requirement of the Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy of further explanation that you may feel necessary in this regard.

Thank you

Sincerely your,

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DECLARATION

We here by declare that thesis is our own work and to the best of our knowledge it contains no materials previously published or written by another person, or have been accepted for the award of any other degree or diploma at sonargaon university or any other educational institution. We also declare that the intellectual content of this thesis is the product of our own work and any contribution made to the research by others, with whom I have worked sonargaon university or elsewhere, is explicitly acknowledged.

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CERTIFICATION OF APPROVAL

This is to certify that the project report entitled “Design, Fabrication, And Performance Analysis of A Solar Powered Air Purifier” submitted by Sheikh Aminul Islam (BME1901017532), Md. Osiur Rahaman (BME2001020266), Md. Faisal Hossain (BME2001020228), Md. Shaon Mridha (BME1903019417), Mohammad Jahidul Islam (BME2001020232) has been accepted as satisfactory partial fulfillment of the requirement for the degree of bachelor of science in Mechanical Engineering on September 2023.

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ABSTRACT

Bangladesh faces significant challenges in maintaining air quality due to rapid industrialization and urbanization, resulting in adverse health effects for its population. This thesis presents the comprehensive development of a solar-powered air purifier uniquely tailored to the environmental conditions of Bangladesh. The integration of renewable energy sources, specifically solar power, addresses both the need for sustainable air purification and the frequent power interruptions in the region. The design phase involves a thorough assessment of the local air quality conditions, energy access, and existing air purification technologies. A novel air purification system is proposed, combining high-efficiency particulate air (HEPA) filters. The solar power system is meticulously designed to provide uninterrupted energy for continuous air purification while incorporating energy storage for nighttime operation. Fabrication of the solar-powered air purifier encompasses material selection, component assembly, and integration of solar panels, energy storage, and air purification units. Emphasis is placed on utilizing locally available resources and materials to ensure cost-effectiveness and accessibility for the Bangladeshi market. Performance analysis focuses on evaluating the efficiency and efficacy of the solar-powered air purifier under real-world conditions in various regions of Bangladesh. Key performance indicators include air purification efficiency, energy consumption, and the system's capacity to operate autonomously with solar power. Extensive field trials and data collection are conducted to assess the system's performance throughout different seasons and climate zones in Bangladesh.

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CHAPTER-1

INTRODUCTION

The most common problem during the summer season is pollution, dust, and allergies. With increase in the number of pollutants in the air, there is an increase in the demand for air purifiers. These air purifiers can be used in offices, homes, commercial places, and if their efficiency is high, then they can also be used outdoors. Air purifier is a device used to remove contaminants like dust particles, cloth fibres etc. present in the air. These devices are claimed to be beneficial to people having allergies, and asthma. The commercially graded air purifiers are manufactured as either small stand-alone units or larger units that can be affixed to an air handling unit (AHU) or to a heating ventilation and air- conditioning (HVAC) unit found in the medical, industrial, and commercial industries. Air purifiers may also be used in industry to remove impurities such as CO₂ from air before processing. A standard air purifier consists of various types of filters, and filter levels to remove the contaminants from the surrounding air [1].

1.1 AIR PURIFIER

An air purifier is a device which removes contaminants from the air in a room. These devices are extremely beneficial for allergy sufferers, asthmatics and at reducing or eliminating second-hand tobacco smoke. They are also extremely useful for reducing pollutants from a room if you live in a highly polluted environment, for instance Dhaka, Chattogram; which are among the most air polluted cities in the world. They also help eliminate virus and bacteria from a room which prevents the spread of disease [2]

USES AND BENEFITS OF AN AIR PURIFIER

Dust, pollen, pet dander, mould spores, and dust mite faeces can act as allergens, triggering allergies in sensitive people. Smoke particles and volatile organic compounds (VOCs) can pose a risk to health. With the advancement in air purification technology, air purifiers are becoming increasingly capable of capturing a greater number of bacterial, virus, and DNA damaging particulates. Air purifiers are used to reduce the concentration of these airborne contaminants and can be useful and fruitful for people who suffer from allergies and asthma [2]

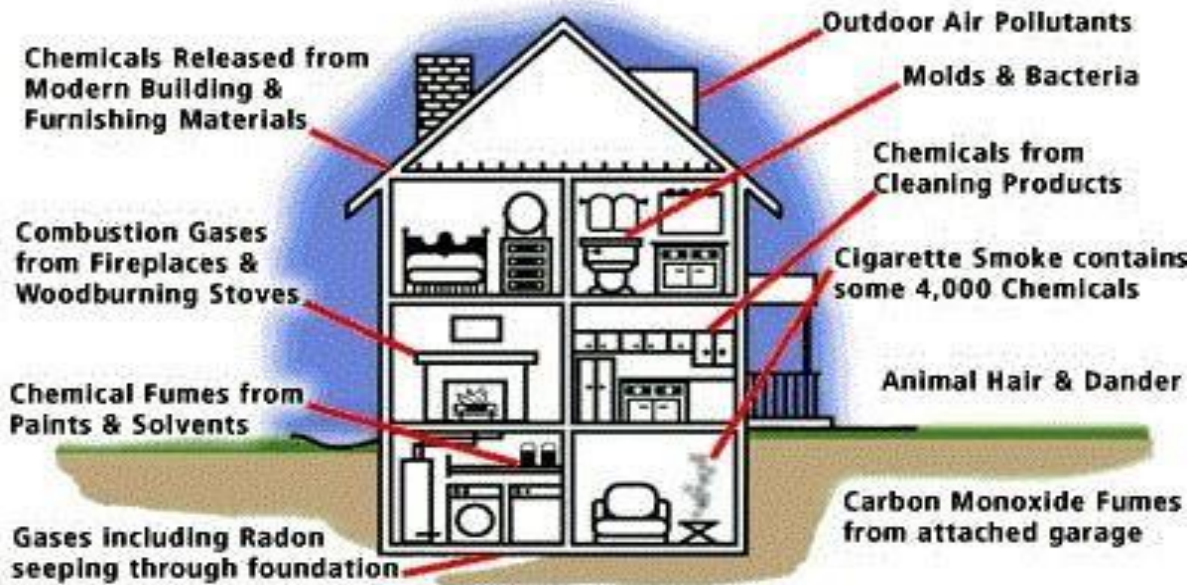


Fig. 1 Impurities in air [1]

Volatile Organic Compounds

Volatile organic compounds, or VOCs, are gases or vapours that are emitted by many everyday household items. They may be emitted by things like new carpeting, paints, adhesives, varnishes, glues, and disinfectants [2].

Odours and Gases

Some air cleaners can largely eliminate odours and gases from the air in a home. They do so with activated carbon filters. These filters use a process called adsorption to force these gases and odours to become attached using a chemical reaction. Common gases and odours include aerosols, tobacco smokes, cooking odours, indoor pesticides, kitty litter, and toxins [3].

Airborne Particles

Airborne particles include things like dust mites, pet dander, pollen, mold, plant spores, and fungi. These types of particles exacerbate conditions like asthma and allergies, so it is smart to eliminate them from the air inside a home. HEPA filters are considered to be the most effective in eliminating these particles, which can vary in size considerably but are all microscopic [4].

WAYS IN WHICH AN AIR PURIFIER CAN CLEAN THE AIR

Several different processes of varying effectiveness can be used to purify air. The most important components of an air purifier are its air filters. Most air purifiers and air cleaners contain at least one air filter. Some use multiple air filters working together to produce the best results. The easiest way to find the right air purifier for you is by looking for air purifiers that have specific types of filters. The main characteristics of today's most popular air filters are given below [5]:

Activated Carbon Filters

Activated carbon uses a chemical reaction called adsorption to pull odours, gases, and vapours from the air. The carbon that is found in these filters is treated with oxygen, which forces millions of small openings to develop [6].



Fig. 2 Activated Carbon [6]

With an increased surface area, an activated carbon filter can pull odours, gases, and vapours from the air for a very long time. Some activated carbon filters can also pull VOCs from the air [6]

Molecular Sieve Filter

A molecular sieve is a material with very small holes of precise and uniform size. These holes are small enough to block large molecules, while allowing small molecules to pass.

Molecular sieves are used as adsorbent for gases and liquids. Molecules small enough to pass through the pores are adsorbed while larger molecules are not [7].



Fig. 3 Molecular Sieve [8]

In an air filter a molecular sieve is most often used in conjunction with an activated carbon filter. This increases the life of the activated carbon filter [8].

Ozone Generators

Although they aren't technically filtering, ozone generators are designed to do the same thing: remove impurities from the air. However, instead of filtering them out, they just make them cling to surfaces around a room [9].

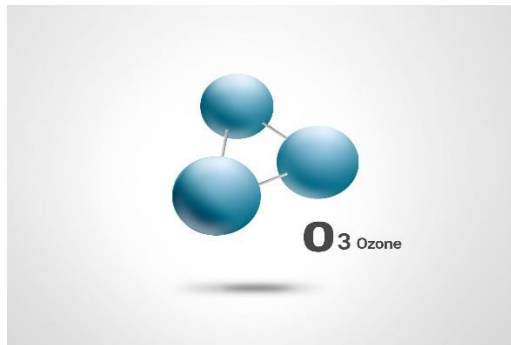


Fig. 4 Ozone [9]

These generators fuse together the oxygen atoms in the room and release ozone as a byproduct. This can be problematic because this reduces the oxygen supply in the room and also ozone is considered to be a lung irritant [9]

Electrostatic Precipitators

The same process that is used with ozone generators is used with electrostatic precipitators. The primary difference is that electrostatic precipitators actually filter impurities out of the air too [10].

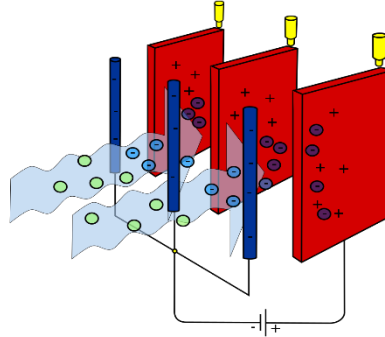


Fig. 5 Electrostatic Precipitators [10]

Charged Media Filters

The description of these filters is almost identical to those of electrostatic precipitators. The only difference is that these filters actually use filters. They don't use plates. As a result, it is necessary to change the filter from time to time [11].

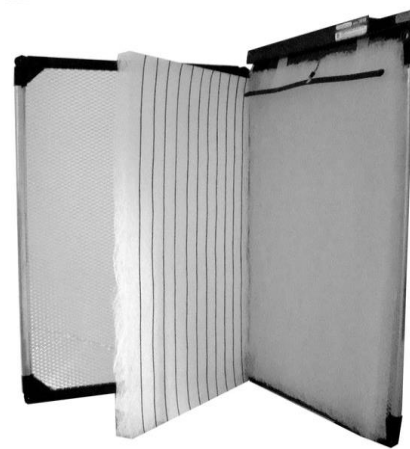


Fig. 6 Charged Media Filter [11]

Elementary/ Pre-Filters

If large particles are allowed to make contact with sensitive filters, air purifiers and air cleaners won't work as effectively or as efficiently. That is why it is extremely important to have a pre-filter as well [12].



Fig. 7 Pre-Filter [12]

A pre-filter's job is to pull larger particles from the air to keep them from being passed along to HEPA filters and other types of filters. In most cases, they can be cleaned again and again [13].

Antibacterial and Germicidal Filters

The only way to eliminate a huge percentage of germs and bacteria from the air is by includes antibacterial or germicidal filters. This ensures that no bacteria or virus is breeding within the filters of the air purifier [13]



Fig. 8 Antibacterial filter [13]

HEPA Filters

High-efficiency particulate air filters, were originally designed to remove radioactive dust particles from the air. However, all HEPA filters are not created equal. The higher the surface area of the filter is, the more effective a HEPA filter [14].



Fig. 9 HEPA Filter

1.2 AIR PURIFIER TECHNOLOGY

The best performing air purifiers feature more than one filter technology, and using HEPA style filtration is the key to optimal results. Filtration performance is not ideal without the use of HEPA air purifiers, and symptoms of particle pollution, like allergies and asthma, are not reduced [15].

HEPA Air Purifiers

Developed in the 1940s, High Efficiency Particulate Air (HEPA) technology was made popular by use in medical cleanrooms, and it is still the most reliable and effective technology used. Air purifiers equipped with a HEPA air filter absorb up to majority percent of all particles, like allergens, pollen, dust, dander, and others that are 0.03 microns and larger in size; harmful indoor air particles that cause allergy and asthma symptoms are measured to be about 0.03 microns or larger. Air purifiers like Alen and Blueair use HEPA in combination with electrostaticity, which allows an electrical charge to trap particles traveling in the air stream. As a result, more particles are gathered and the charged particles are brought directly to the HEPA air filter which captures them. Bacteria, dust, and pollen and other microscopic particles are absorbed by HEPA air filters, so the air that re-circulates in your home is clean, fresh, and scarce of harmful contaminants [16]

Electrostatic Air Purifiers

An electrostatic air purifier is very similar to HEPA air purifiers, except they do not use air filters. Electrostatic air purifiers use an electrical charge to trap particles traveling in the air stream. As a result, the charged particles stick to the sides of the internal filtration system on collection plates, but only about 30% of particles are removed from your indoor air.[17] Electronic air purifiers are low maintenance and only require cleaning of the collection plates for optimal efficiency. However, like with the Ionic Breeze air purifier from Sharper Image, electronic air purifiers were found not to take in all the air in an enclosed room. It was measured to have left about 5% of the contaminated air in the room to circulate without it ever being absorbed by the purifier. Consumer Reports gave the Ionic Breeze air purifier a "poor" rating. Although they are readily available, consumers who research air purifier technologies before making a purchase are sure to avoid Ionic Breeze and electrostatic models [17].

Ozone Generators

Ozone generators are air purifiers that intentionally produce ozone. Not all are effective, but some are not even appropriate for home use, like ozone generators. Ozone generators are not effective air purifiers for your home; they can be harmful to your family and can cause health problems, including respiratory tract irritation and breathing difficulty. Historically, ozone generators have been used in commercial applications to purify the air and remove airborne particles, chemicals, mold, viruses, bacteria, and odours. However, ozone is not effective at cleaning the air except at extremely high, unsafe ozone levels [18].

Type Of Air Purifiers	Pros	Cons	Recommended
HEPA Air Purifiers	<p>Most effective technology for air purifiers</p> <p>Removes up to majority percent of parti.</p> <p>Removes up to majority percent of particles that pass through</p> <p>Used worldwide in medical cleanrooms.</p>	Regular filter replacements	yes
Electrostatic Air Purifiers	No air filter replacement necessary	<p>Removes only 30% of particles from the air.</p> <p>Does not clean all of the air in an enclosed space.</p> <p>Does not use HAPA air filter.</p>	no
Ozone Generator	Removes strong odours Kills bacteria, mould, and other microorganism.	Extremely dangerous lung irritant California Air Resources Board restricts technology sold in the state of California	no

Table No. 1 Purifier advantages [18]

1.3 HEPA TECHNOLOGY

HEPA is an acronym for High Efficiency Particulate Air and is a technology that has been used for many years to filter particles. HEPA filters must meet a standard of trapping at least majority percent of all particles larger than 0.3 microns. The human eye can only see particles larger than 10 microns; so particles caught in a HEPA filter such as chemicals, bacteria and viruses cannot be seen. Because HEPA filters are able to trap mold and bacteria, they create a more sanitary environment. Additionally, this does not generate ozone or any other harmful by-products [19].

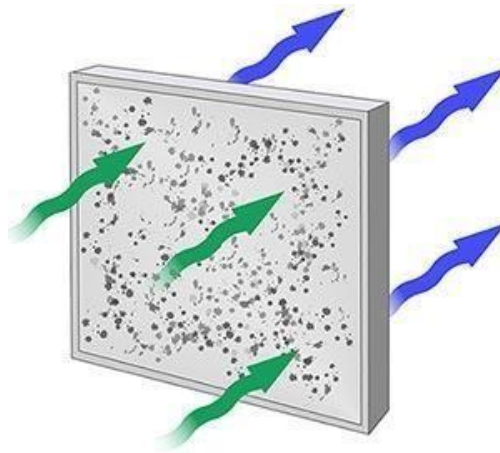


Fig. 10 HEPA Filter Working

HEPA Filter

The HEPA filter is a very fine fiber-like material that has been folded back and forth to create the shape of an accordion. This accordion shape creates a maze of randomly arranged fibers and presents a very large surface for air to be pushed through by the air purifier fan. Airflow must have an opportunity to pass through the filter in order for it to be cleaned. The more times airflow passes through the filter in an hour, the cleaner the air will become. As the HEPA filter becomes full, air will no longer be able to pass through and a new filter will be needed; however, a HEPA filter will typically last 2 to 4 years [20].

Components of a HEPA Filter

HEPA filters are made of boron silicate microfibers formed into a flat sheet by a process similar to making paper. Flat filter sheets are pleated to increase the overall surface area. Pleats are separated by baffles which direct the airflow through the filter. Filter media is very delicate and should never be touched [20].

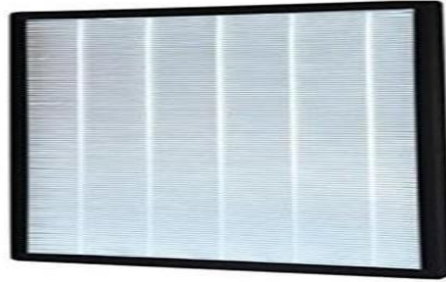
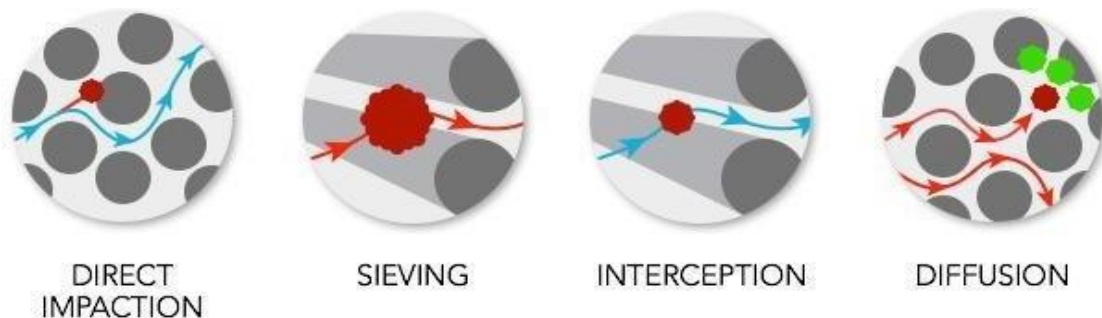


Fig. 11 HEPA Filter

How a HEPA Filter Operates

Large particles will not be able to pass through the openings of the fibers and will immediately get caught. The smaller particles will get caught by one of four mechanisms [20].



- **Direct Impaction:** Large contaminants, such as certain types of dust, mould, and pollen, travel in a straight path, collide with a fiber, and stick to it.
- **Sieving:** The air stream carries a particle between two fibers, but the particle is larger than the gap, so it becomes ensnared.
- **Interception:** Airflow is nimble enough to reroute around fibers, but, thanks to inertia, particles continue on their path and stick to the sides of fibers.
- **Diffusion:** Small, ultrafine particles move more erratically than larger ones, so they're more likely to hit and stick to fibers.

HEPA air purifiers are the most effective at trapping airborne particles; however, they do not remove odours, chemicals or gases. Therefore, most HEPA air purifiers have some level of activated carbon-based material to absorb odours and chemicals not caught by the HEPA filter [20]

CLASS OF HEPA FILTER

Several classes of HEPA filters by their retention at the given most penetrating particle size (MPPS) according to European Norm 1882:2009:

HEPA class	Retention (total)	Retention (local)
E10	> 85%	---
E11	> 95%	---
E12	> 99.5%	---
H13	> 99.95%	> 99.75%
H14	> 99.995%	> 99.975%
U15	> 99.9995%	> 99.9975%
U16	> 99.99995%	> 99.99975%
U17	> 99.999995%	> 99.9999%

Table No. 2 HEPA Filter classes[21]

Types of HEPA Filter

An ideal HEPA filter for the best air purifier is the one that captures majority percent of minute dust particles as minute as 0.3 microns. Only a real HEPA Filter can achieve the above-mentioned objective. Thus, this way you can adjudicate whether your filter is a true HEPA Filter or not [21].

HEPA Filter Strengths

1. Remove dust, dust mites, pet dander, pollens, mold, some bacteria and other common indoor allergens.
2. Air contaminants that have been trapped in the filter won't be released back into the air.
3. Does not generate ozone or harmful by-products [21].

HEPA Filter Weaknesses

4. Won't remove odours, gases, chemical fumes, volatile organic compounds, cigarettes, smoke, and ultra-small particles, viruses and germs (0.01 microns and below).[22]
5. HEPA filter works passively. It requires a fan to draw in air in order to trap air contaminants.
6. Bacteria and viruses trapped in the filter can breed and reproduce.

MERV Rating	Air filter will trap particles sized .3 to 1.0 microns	Air filter will trap particles sized 1.0 to 3.0 microns	Air filter will trap particles sized 3.0 to 10 microns	Filter Type & Particles Removed
MERV 1	<20%	<20%	<20%	Fiberglass and Aluminum Mesh pollen, dust mites, spray paint, carpet fibers, pet dander
MERV 2	<20%	<20%	<20%	
MERV 3	<20%	<20%	<20%	
MERV 4	<20%	<20%	<20%	
MERV 5	<20%	<20%	20% - 34%	Disposable Filters mold spores, kitchen aerosols, hair spray, furniture polish, household cleaning sprays
MERV 6	<20%	<20%	35% - 49%	
MERV 7	<20%	<20%	50% - 69%	
MERV 8	<20%	<20%	70% - 85%	Home Box Filters lead dust, flour, auto fumes, welding fumes
MERV 9	<20%	>50%	85% or better	
MERV 10	<20%	50% - 64%	85% or better	
MERV 11	<20%	65% - 79%	85% or better	Commercial Filters bacteria, wildfire smoke, respiratory droplets
MERV 12	<20%	80% - 90%	90% or better	
MERV 13	>75%	90% or better	90% or better	
MERV 14	75% - 84%	90% or better	90% or better	
MERV 15	85% - 94%	95% or better	90% or better	
MERV 16	95% or better	95% or better	90% or better	
MERV 17	99.97%	99% or better	99% or better	HEPA and ULPA viruses, carbon dust
MERV 18	99.997%	99% or better	99% or better	
MERV 19	99.9997%	99% or better	99% or better	
MERV 20	99.99997%	99% or better	99% or better	



Table No. 3 Filter types [23]

1.4 TECHNOLOGY COMPLIMENT HEPA FILTER

The best technology to pair with HEPA style filtration in air purifiers really depends on your concern. There are many different technologies that are used in air purifiers with HEPA style filtration, such as activated carbon, pre-filters, ultraviolet light, and ionizers. Choosing the best air purifier with the most efficient technology can be easy with some research and comparison. While searching through many air purifiers to find your perfect solution, be aware that the technology used is the most important factor you should consider.[23]

Pre-Filters

A pre-filter captures the largest particles before they reach the more expensive HEPA filter. Most of the particles in your air are large particles like dander and dust, not tiny ones like pollens and microbes. Even though HEPA filters have a large number of pleats to maximize their surface area, they can fill up quickly if larger particles are not pre-filtered out .[24]

Activated Carbon

Elements like activated carbon, zeolite, or potassium permanganate are added to air purifier filters to increase efficiency to the filtering system. These elements work to absorb smoke, gases, chemicals, and odours that are present in the air. Activated carbon neutralizes odours and traps harmful chemicals and gases in its pores to provide relief from activities like second-hand smoke, off-gassing from plastics, and harmful fumes produced from renovations. An effective filtering system that is also equipped with chemical adsorption materials can produce cleaner and fresher-smelling air .[25]

Ultraviolet Light

Ultraviolet light (UV) technology is key to neutralizing viruses and bacteria that accumulate on air purifier air filters. It is important to use the UV technology in combination with HEPA air filters and possibly activated carbon. Without a particulate filter system like a HEPA air filter, too many microorganisms may be hidden from the UV light, since it is not easily located on an air filter .[25]

1.5 PROBLEM STATEMENT:

The objective of this project is to design and develop an innovative air purifier solution that can effectively and efficiently remove pollutants, allergens, and other harmful particles from indoor air. The solution should not only focus on air purification but also aim to address some common challenges and limitations associated with traditional air purifiers.[26]

OBJECTIVES

The main objective of making this machine is to do technical advancement in the air purification. It helps to clean air in pollutant area and provides quality of air. Design an Air Purifier which operates with HEPA filter and Activated Carbon. It is capable of filtering majority percent airborne particles larger than 0.03 micron along odour of gases. This filter can work in absence of electricity by using solar energy. Another purpose of this filter is to overcome the use of traditional marking methods which is done with the help of sprinkling of water to purify air can be reduced. A World Bank study, Breathing Heavy - New Evidence on Air Pollution and Health in Bangladesh, estimated 78,145 to 88,229 deaths was caused by air pollution in 2019 , which is the second strongest risk factor, causing most deaths and disabilities in the country between 2009 and 2019.[24]

Alternative Technology	PROS	CONS
Pre-Filters	<ul style="list-style-type: none"> • Captures large particles • May be washable • Extends life of HEPA filter 	<ul style="list-style-type: none"> • Requires maintenance
Activated Carbon	<ul style="list-style-type: none"> • Absorbs odours, gases, and chemicals • Leaves space smelling fresh. • Removes Tobacco smoke and pet odours 	<ul style="list-style-type: none"> • Vary widely depending
Ultraviolet Light	<ul style="list-style-type: none"> • Neutralizes Microorganisms like bacteria and viruses 	<ul style="list-style-type: none"> • Proper safety measures & Requires maintenance

Table No. 4 Alternative Filters [26]

CHAPTER-2

LITERATURE REVIEW

HEPA filters were originally classified as top-secret, developed by the US Atomic Energy Commission to protect soldiers from radioactive particles on the battlefield. During World War II, scientists involved in the Manhattan Project used HEPA masks to guard against contaminants from the atomic bomb.

Although these early HEPA masks couldn't possibly protect people from atomic radiation, the research spawned the HEPA filter, which provided protection against chlorine gas, mustard gas, and flame throwers. It was not until the 1960s that specifications were standardized and the term HEPA or "High Efficiency Particulate Air" was officially coined by the Department of Energy (DOE).

As defined by the DOE, HEPA filters remove at least majority percent of dust, pollen, mould, bacteria and any airborne particles with a size of 0.3 microns. From the beginning, HEPA filters were employed to filter out highly hazardous aerosols, toxic carcinogens, radioactive particles, and biohazardous contaminates.

In Germany, brothers Klaus and Manfred Hammes purchased a patent for a simple air filtration system. Using a fiberglass pad attached with small magnets to the air outlet of a residential oil oven, the Hammes brothers were able to filter soot from the air. In 1963, the Hammes brothers simple but effective filter became the first air cleaner to be utilized in homes across Germany .

In the same year, US Congress passed the Clean Air Act of 1963 to set standards for the reduction of air pollution through fuel emissions standards. Although it was not Congress first attempt at reducing air pollution, the Clean Air Act of 1963 alerted scientists and consumers of the need to protect our lungs from pollutants such as perfumes, building materials, chemicals, pesticides, and allergens.[27]

No longer classified as top-secret, HEPA air filters became popular in the 1970s and 1980s as more consumers became concerned about air pollution. With the introduction of dozens of products featuring HEPA filters, new and exciting ways to control allergies and asthma finally became widely available for residential use. Originally, the first HEPA air purifiers were bulky, difficult to operate, and traditionally used only in hospital and pharmaceutical settings and[27]

among computer chip manufacturers. Then businesses began to take notice of indoor air quality concerns among residential consumers.[27]

In response to the growing demand for cleaner air, Incen AG, the Hammes brothers newly formed company moved to Switzerland and began developing and manufacturing residential air purifiers in 1971. After many years of international success for Incen AG, Frank Hammes, son of Klaus Hammes, began to distribute cabin air filters as add-on accessories for Mercedes-Benz automobiles in 1990.[28]

In 1991, Frank Hammes formed IQAir North America, which has promoted the continual growth and success of the air purification industry.[28]

In 1991, through the amazing technology of True Medical HEPA and Activated Carbon, Richard Taylor created a filter that addressed the issues of environmental particulate contamination, chemical toxicity, and odours. It was then that he and his wife Joyce founded Austin Air Systems Limited. Based out of Buffalo, NY, Austin Air introduced a pre-filter that ensured a HEPA filter life unequalled to anything in the industry. Austin Airs 360-degree intake system draws air into all sides of the air cleaner, maximizing efficiency and delivering more clean air faster. With the largest air cleaner manufacturing facility in the world, Austin Air continues to produce all the parts for their fantastic air purifiers [28].

Established in 1992, AllerAir quickly became a trusted name in air purification. After a family member of AllerAir founder Sam Teitelbaum developed Multiple Chemical Sensitivity (MCS), Teitelbaum and partner Wayne Martin decided to develop their own air cleaner. Using the combination of true HEPA filters and a MAC-B (mass activated carbon bed) filters, which contain pounds of carbon, AllerAir created an air purifier that safely and effectively removes chemicals, gases, and odours from the air. With offices in the United States, Italy, and Canada, AllerAir air purifiers are used by the Mayo Clinic, IBM, Gucci, Prada, and the U.S. Army. With more than 100 model to choose from, AllerAir air cleaners are efficient, practical, and cost effective[29].

With headquarters in Stockholm, Sweden, and Chicago, the Blue air air purifier company is committed to creating a healthier environment both indoors and out. Founded in Sweden in 1996, blue air quickly earned a reputation for high performance, technological innovation, and quality design. A revolutionary combination of mechanical and electrostatic filtration allows blue air purifiers to capture majority percent of irritating particles, gases, and odours. With

more than five different models, these powerful yet near-silent air cleaners provide a visually-pleasing form and highly effective function.[29]

Now a global leader in the production of specialty products and chemicals and a subsidiary brand of Kaz, Honeywell started as a hot water heater company in 1906 and has a longstanding tradition of supplying safe, reliable, and high-quality products. Acquired by Kaz in July of 2002, Honeywells indoor air quality products continually meet and exceed the American Lung Associations Health House guidelines with meaningful innovations based on consumer research and insights. With the use of permanent, lifetime HEPA filters, Honeywell air cleaners remove majority percent of all common, household particles such as dust, pollen, tobacco, smoke, and cat dander. The Honeywell glass-fiber HEPA material helps remove airborne particles without the use of expensive ultraviolet bulbs, chemicals, or other treatments. With a diversity of products to fit your needs, Honeywell offers a series of Home Comfort and Indoor Air Quality Solutions [30].

In 2002, IQ Air air purifiers became the first air cleaners to incorporate H13 class certified HEPA filters, which capture up to 100 times more particles than conventional HEPA filters. H13 class certified HEPA filters, up to that point, had only been used in hospital clean rooms.[31]

Although no longer a top-secret government project, air purifiers still hold the secrets to cleaner air and healthier environments for many asthma and allergy sufferers. Today HEPA air purifiers and filters are used in a variety of critical filtration applications in nuclear, electronic, aerospace, pharmaceutical and medical fields, as well as in homes around the world

CHAPTER-3

DESIGN AND FABRICATION

Creating a solar-powered air purifier involves several key components. Here's a high-level description of the major components you would need for such a project:

3.1 COMPONENTS OF PURIFIER

Solar powered air purifier consists of following components:

Fan: A fan or blower is used to draw air into the purifier. It plays a crucial role in the circulation of air through the filtration system. The fan ensures a continuous flow of air through the purifier, allowing for effective filtration.



Fig. 12 Fan

Battery: Some solar air purifiers include a battery system to store excess energy generated by the solar panels. This allows the purifier to operate during periods of low sunlight or at night when solar power is not available.



Fig. 13 Battery

Solar Panel: The heart of a solar air purifier is its solar panels. These panels are responsible for capturing sunlight and converting it into electrical energy. The electricity generated by the solar panels powers the various components of the air purifier, including the fan and filtration system.



Fig. 14 Solar Panel

Controller: A controller connects Fan, Battery & Solar Panel together. Power is supplied from the battery through controller, the controller indicates whether battery is charged or not. It connects the solar panel to the battery for charging.

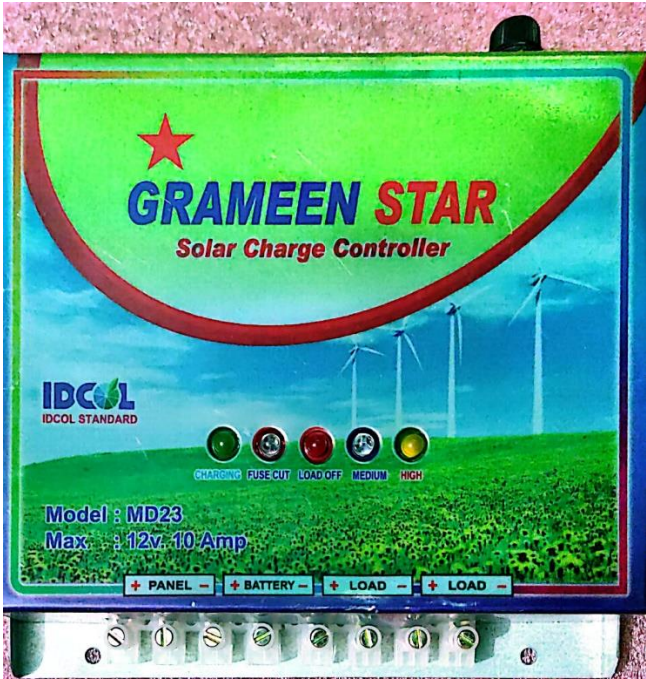


Fig. 15 Solar Controller

Filter: A HEPA filter has been installed on the both side of purifier. It can eliminate particles which are larger than 0.03 micron with filtration rate of majority percent. The bacteria, dust, allergens, viruses, fungi and other small and tiny particle not go through HEPA filter.

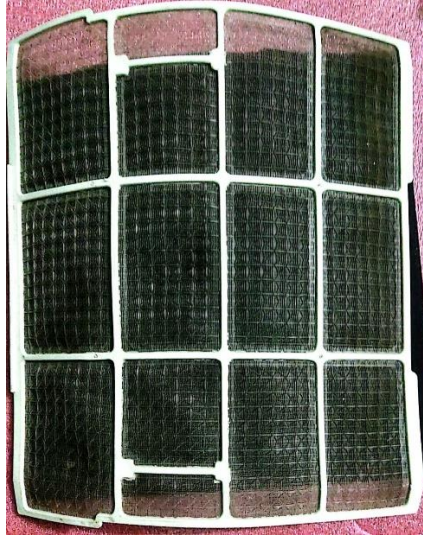


Fig. 16 HEPA Filter

Wires: 5 mm wires have been used to in order to make necessary connections among various electrical components of purifier.



Fig. 17 Wires

MATERIAL USED

Body: Its made hard fiberboard, Hard fiberboard is also made of wood fibers. These are wetted and compressed at a high temperature on a sieve that provides the structure of the plate.



Fig. 18 Body

Adhesive Tapes: Adhesive tapes is a combination of a material and an adhesive film and used to bond or join objects together instead of using fasteners, screws or welding. Applying adhesive tapes in instead of mechanical fasteners enables you to use lower temperature application, which can simplify the manufacturing processes.



Fig. 19 Adhesive Tapes

Super Glue: Super glue, or cyanoacrylate, is the general name for a family of fast- acting adhesives with industrial, medical and household uses. It usually comes in a small tube, and is often sold as “Super Glue”.



Fig. 20 Super Glue

3.2 FINAL FABRICATED PROJECT :

The device features photovoltaic panels that capture sunlight and convert it into electricity. This clean and renewable energy source powers the air purification process, reducing reliance on conventional electricity and lowering energy costs.

Equipped with advanced air purification technology, such as HEPA filters the solar-powered air purifier effectively removes pollutants, allergens, and pathogens from the air. This ensures a healthier and safer indoor environment for occupants.



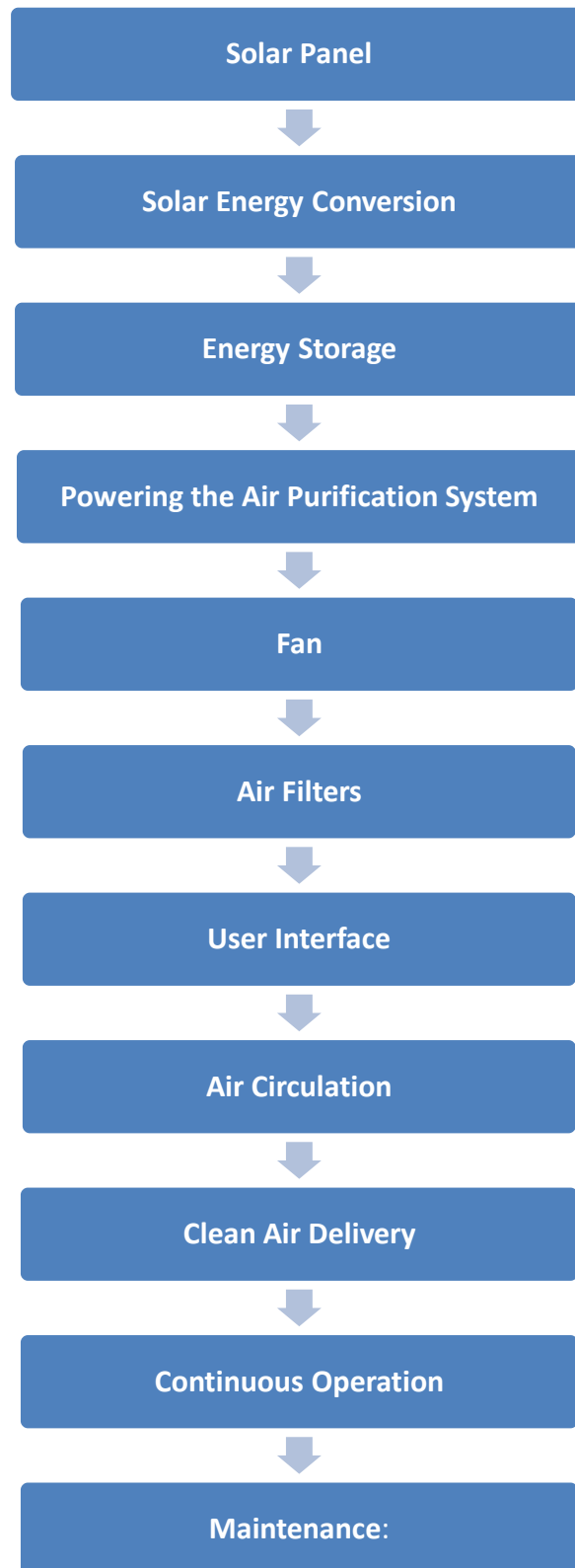
Fig. 21A Solar Powered Air Purifier



Fig. 21B Solar Powered Air Purifier

3.2 WORKING

The working of a solar air purifier involves harnessing solar energy to power an air purification system. Here's a step-by-step explanation of how a solar air purifier typically operates:



Solar Panel: The core component of a solar air purifier is the solar panel or photovoltaic (PV) array. Solar panels consist of multiple solar cells that convert sunlight into electricity. These panels are typically installed on the exterior of the device or in a location where they can receive direct sunlight. [40]

Solar Energy Conversion: When sunlight strikes the surface of the solar panels, it excites electrons within the solar cells, creating a flow of direct current (DC) electricity. The amount of electricity generated depends on factors like the size and efficiency of the solar panel, as well as the intensity of sunlight. [40]

Energy Storage: In many cases, solar air purifiers include an energy storage component, such as a battery. This allows the system to store excess electricity generated during sunny periods for use when sunlight is unavailable (e.g., at night or during cloudy weather). Energy storage ensures continuous operation of the air purification system. [40]

Powering the Air Purification System: The electricity generated by the solar panels or drawn from the battery powers the air purification system. This system typically includes the following components: [40]

Fan: The fan is responsible for drawing in ambient air and pushing it through the air purification unit.

Air Filters: The air passes through one or more types of filters, such as HEPA (High-Efficiency Particulate Air) filters. These filters remove particulate matter, allergens, odors, from the air.

User Interface: Solar air purifiers often have a user-friendly interface that allows users to monitor air quality, adjust settings, and receive alerts about filter replacement or system maintenance.

Air Circulation: The fan circulates the air through the filtration and purification stages, removing pollutants and improving indoor air quality.

Clean Air Delivery: After passing through the filters and purification stages, the clean and purified air is released back into the indoor environment.

Continuous Operation: During sunny days, the solar panels generate electricity to power the air purification system continuously. If the system has an energy storage component, it can operate during periods of low or no sunlight.

Maintenance: Periodic maintenance is required for solar air purifiers. This includes cleaning the solar panels to ensure optimal energy generation and replacing air filters as they become saturated with pollutants. [40]

CHAPTER-4

FUTURE SCOPE AND APPLICATION

4.1 FUTURE SCOPE

Increase in vehicular population, severe construction activities, and industries are largely contributing to an increase in outdoor pollution across Indian cities. It is quite evident that, with a growing economy and over 125 billion people to feed, the destruction will continue and more forests will be cut and space created for infrastructure. So, there will be consequences for these actions. Starting from groundwater, the crops and the air – they are all becoming toxic. Obviously, the coming generations will pay heavily for this irresponsible action by us. What we need are consciousness and actions that can at least reduce the burden to the only planet that we have [41].

While most of us have taken control of the food and water intake, but the air we breathe is ignored completely. Respiratory symptoms, especially among children are on the rise which signals in the effects of toxins that are causing severe damage to the respiratory system. It is also evident from the increase in your trips to the doctor or medication [42]. Air pollution is responsible for wheezing, sneezing, cough, asthma, and various other illness including heart attack and lung cancer. Thus, it is important to not just purify the indoor air, but also to avoid the pollutants from entering and keeping the environment clean and pure. In today's time, air purifiers are as much a necessity as a water purifier [43].

Several studies, including those of British Allergy Foundation, have proven that breathing air clean and purified by Sharp air purifiers reduce the number of toxins entering our body, thereby decreasing the need for medication or taking days off from work. This is missing from most brand commitments since they are too occupied with reducing dust or other particles and have diverted from the actual need and benefits that a consumer expects [44].

Most people mistake the indoor air to be safe and free from pollution, however, due to poor ventilation and lack of sunlight, each and every activity that we do indoor contributes to adding toxins in the air we breathe. For example, kitchen smoke, mosquito repellents, cleaning solutions, and electronic appliances they all contribute equally to poison the air we breathe.

Apart from many other methods to reduce the airborne toxins in an indoor space like plants, air purifiers are gradually gaining momentum. However, due to lack of instant gratification or immediate result, the category has still not become popular among consumers. Each consumer, in spite of their problems, is afraid to take a decision that involves an investment of around 20K or more [45].

As people's awareness increases and the demand for air purifiers rises, so does the requirement for advanced technologies. Almost all the leading brands spend a lot of time and resources on the R&D of their product and the air purifier market is expected to witness a rise in the demand of purifiers. At present, technologies such as air purifiers with mosquito catcher, car purifiers, and air sterilizers are already prevailing in the market, but the market for such products is still very small and limited [45].

Currently, most Air Purifiers come with HEPA& Carbon Filters which can provide solution up to an extent and be going forward and as consumer awareness increases demand for higher technology marvels like Plasma cluster Ion Technology will be an accepted standard so as to get holistic solution towards Air Pollution. Also, confused messaging with respect to performance indicators of Air Purifiers i.e., inbuilt Air Quality monitors which are inefficient in capturing complete constituents of Air Pollution and can only provide mental satisfaction to users by providing inconsistent readings (only on PM 2.5 which constitute only 25 percent of Indoor Air Pollution) will see an end [45].

Although the Indian air purifier market is still in its nascent stage, the market has a vast scope, as people are getting aware and conscious about the effects of air pollution on their health, their family, and especially on little kids. Innovations in air purification systems need to be holistically devised to kill bacteria and virus, reduce odours, and remove dust, pollen, and other pollutants from the atmosphere

4.2 APPLICATION

Medical, Commercial, Institutional, Industrial, and Military Applications

Since 1985 Pure Air Systems, Inc. has been manufacturing commercial grade HEPA and carbon-based air filtration systems for the commercial and residential markets. Here are some of the applications where our products are being used [46]:

Medical

Hospitals: Use of HEPA systems in patient care rooms where either a positive or negative HEPA filtered environment is required. Typically used for infection control or isolation for communicable disease control.

Clinics: Use of HEPA systems for reduction/removal of airborne pathogens, allergens and bacteria to maintain clean environment for outpatient procedures.

Laboratories: Use of HEPA systems in medical labs and dental labs

Pharmaceutical Manufacturing: Use of HEPA systems for containment of chemical compounds during the manufacture and development of pharmaceutical drugs

Institutional

Universities: Use of HEPA and Carbon systems for R&D labs for reduction/removal of airborne contaminants and/or pathogens during various phases of the research cycle.

Pre-Schools and Secondary Educational Facilities: Use of HEPA systems in pre-schools to reduce levels of airborne pathogens and minimize spread of communicable disease. Use of HEPA systems in High Schools for overall air filtration of occupied areas

Commercial

Household Health and Personal Care Products: Use of HEPA and Carbon-based systems for reduction/removal of contaminants associated with the design and development of various chemical and compound-based health care and cosmetic products.

Food Products and Beverages: Use of HEPA systems to maintain mid-level clean room environment for packaging and processing of food grade products. This includes the bottling process for many alcoholic and non-alcoholic beverages.

Retail–Restaurant: Use of HEPA and Carbon systems for removal of odours and airborne particulates in food service and various retail facilities. Also used for removal of cigarette and cigar smoke in those bars and restaurants that allow smoking.

Apartments and Hotels: Use of HEPA systems in apartment complex HVAC systems (where individual air handlers are used) and in high end Hotels for meeting and conference rooms

Industrial

Microelectronics: Use of HEPA and Carbon systems in the manufacture of microchips and other dust sensitive electronic components. Typically, these types of products have to be fabricated in a clean-room type of environment.

Optics: Use of HEPA systems to maintain clean room environment in the manufacture of precision optics for commercial and military use.

Precision Component Manufacturing: Use of HEPA systems for reduction/removal of fine dust generated in the manufacturing of precision components to minimize maintenance issues with particulate getting into process equipment.

Testing Laboratories: Use of HEPA systems to remove fine airborne particulate generated during various phases of compound testing (i.e. mineral labs, precious metal labs).

Automotive: Use of HEPA systems in the paint and coatings labs and R & D facilities

Military

Aerospace Guidance Systems: Use of HEPA systems in the manufacture and assembly of highly sophisticated, precision guidance systems for all military aircraft, satellites and unmanned systems. These systems are always assembled in clean room environments.

Chemical and Biological Systems: Use of HEPA systems for protection of occupants in the development and testing of certain chemical and biological compounds

CHAPTER-5

RESULTS & DISSCUSSION

OUR AIR PURIFIER SIZE :

L= 250mm, W=200mm, H= 500mm, suction & discharge port dia 200mm.

1) We Know that,

$$Q=A \times V$$

Here, Q= air flow (CFM), A= Discharge port area (sft), V= air velocity (fpm)

$$Q= 200 \text{ CFM}$$

$$A= \pi r^2$$

$$=3.1416 \times (0.333)^2$$

$$=0.3482 \text{ sft}$$

$$V=Q/A$$

$$=200 \text{ cfm} / 0.3482 \text{ ft}^2$$

$$= 574.7 \text{ fpm.}$$

2) We Know that,

$$Q=A \times V$$

Here, Q= air flow (CFM), A= Discharge port area (sft), V= air velocity (fpm)

$$V= 574.7 \text{ fpm}$$

$$A= \pi r^2$$

$$=3.1416 \times (0.333)^2$$

$$=0.3482 \text{ sft}$$

$$Q= AV$$

$$= 0.3482 \times 574.7$$

$$= 200 \text{ CFM}$$

- HEPA filter remove majority percent of particle that have a size of less than 0.03 micron.
- HEPA filter require frequent replacement after 6-8 month.

Power consumption (volt)	Cost (BDT)	Noise level (Db)	Efficiency
12 Volt	4000/-	47(high speed) 35(medium speed) 28(low speed)	Majority percent

Table No.5 Project Specification

From the information above, we can conclude that the filter built is affordable and about majority percent efficient.

A SOLAR-POWERED AIR PURIFIER CAN OFFER SEVERAL BENEFITS FOR BOTH INDIVIDUALS AND SOCIETY AS A WHOLE.

Reduced Energy Costs: Solar power harnesses energy from the sun, which is a free and renewable resource. Using solar power for an air purifier can significantly reduce electricity bills, making it a cost-effective solution in the long run. This is especially important in areas with unreliable or expensive grid electricity.

Environmental Benefits: Solar power is a clean and sustainable energy source that produces no greenhouse gas emissions or air pollutants during operation. By using solar energy to power air purifiers, you reduce the carbon footprint associated with electricity generation, contributing to a cleaner and healthier environment.

Improved Air Quality: Air purifiers remove pollutants and allergens from the air, leading to better indoor air quality. This can have a positive impact on people's health, reducing the risk of respiratory problems, allergies, and other health issues related to poor air quality.

Energy Independence: Solar-powered air purifiers can operate independently from the grid, which can be especially beneficial in remote or off-grid areas. This promotes energy independence and resilience, ensuring that air purification is available even in areas with unreliable or no access to electricity.

Public Health: Cleaner air benefits not only individuals but also society at large. By reducing air pollution indoors and outdoors, solar-powered air purifiers contribute to public health by lowering the incidence of respiratory diseases, cardiovascular problems, and other health issues related to air pollution.

Emergency Response: Solar-powered air purifiers can be deployed in emergency situations, such as natural disasters or wildfires. They can provide critical air purification when traditional power sources are disrupted, helping to protect the health and well-being of affected communities.

Promotion of Renewable Energy: Using solar power for air purification raises awareness of renewable energy sources and encourages their adoption. This can drive further investment in solar technology and contribute to the transition to a more sustainable energy mix.

Reduced Noise Pollution: Solar-powered air purifiers are typically quieter than traditional gasoline or diesel-powered generators. This reduction in noise pollution can improve the quality of life for individuals living near these devices.

Long-term Sustainability: Solar panels have a long lifespan, often exceeding 25 years, and require minimal maintenance. This makes solar-powered air purifiers a sustainable and reliable solution for improving air quality over the long term.

CHAPTER-6

LIMITATION AND RECOMMENDATION

LIMITATION :

Solar-powered air purifiers offer several advantages, but they also come with certain limitations:

Intermittent Operation: Solar power generation depends on sunlight, which can be inconsistent due to weather conditions and time of day. This intermittency can lead to periods of reduced or no air purification during cloudy days or at night unless there is a backup energy source.

Energy Storage: To maintain consistent air purification, solar-powered air purifiers often require energy storage solutions like batteries. However, these batteries can add to the cost and maintenance of the system. Battery lifespan and efficiency can also degrade over time.

Limited Capacity: The size and capacity of the solar panels on the air purifier may limit the device's ability to handle large indoor spaces or areas with very high levels of pollution. Larger spaces may require multiple units or supplementary power sources.

Initial Cost: Solar-powered air purifiers tend to be more expensive upfront compared to conventional air purifiers. While they can reduce electricity bills over time, the initial investment might be a barrier for some consumers.

Maintenance and Cleaning: Solar panels require regular cleaning to maintain optimal efficiency. Dust, dirt, and debris can accumulate on the panels, reducing their ability to generate power. This maintenance can be cumbersome, especially in dusty environments.

Environmental Impact: The production of solar panels and batteries involves the use of raw materials and energy, which can have environmental impacts. Additionally, the disposal of batteries at the end of their life cycle requires proper recycling to minimize environmental harm.

Limited Sunlight Availability: In regions with limited sunlight or prolonged periods of overcast weather, solar-powered air purifiers may not operate at peak efficiency, potentially compromising air quality during these periods.

Complex Installation: Installing solar-powered air purifiers can be more complex than traditional models, particularly if they require battery storage. It may involve professional installation, which adds to the overall cost.

Aesthetics: The need for solar panels can affect the design and aesthetics of the air purifier, which may not be suitable for all indoor spaces.

RECOMMENDATION:

Improving the performance of a solar powered air purifier can enhance its efficiency and effectiveness in purifying indoor air. Here are some processes and strategies to consider:

Increase Solar Panel Capacity: Install larger or more efficient solar panels to capture more sunlight and generate additional power. This can help ensure that the air purifier operates at optimal levels even during cloudy days.

Energy Storage Enhancement: Upgrade the energy storage system by using high-capacity and long-life batteries. This will provide consistent power to the air purifier, ensuring uninterrupted operation, even during nighttime or low-sunlight periods.

Dual Power Sources: Implement a hybrid system that combines solar power with a backup power source, such as a grid connection or a wind turbine. This ensures continuous operation in all weather conditions.

Maximum Sunlight Exposure: Properly position and angle the solar panels to maximize exposure to sunlight throughout the day. Regularly clean the panels to remove dust and dirt, which can reduce their efficiency.

Efficient Airflow Design: Optimize the airflow design of the air purifier to minimize energy consumption. Ensure that the system efficiently circulates and filters indoor air without unnecessary power usage.

Smart Control System: Incorporate a smart control system with real-time monitoring and automation features. This allows the air purifier to adjust its operation based on the indoor air quality and available solar power, maximizing efficiency.

Energy-Efficient Components: Use energy-efficient components, such as low-power fans and motors, to reduce the overall energy consumption of the air purifier.

Energy Storage Management: Implement advanced energy management systems to optimize battery charging and discharging cycles, increasing the lifespan of the batteries and overall system reliability.

Remote Monitoring and Control: Enable remote monitoring and control capabilities through a mobile app or web interface. This allows users to adjust settings and receive performance alerts, ensuring efficient operation.

Energy Harvesting: Explore energy harvesting technologies, such as piezoelectric or thermoelectric materials, to capture additional energy from the environment and supplement solar power generation.

Efficient Filtration Media: Use high-quality and efficient filtration media in the air purifier to ensure that it effectively removes pollutants with minimal energy consumption.

Regular Maintenance: Establish a maintenance schedule to clean and maintain both the solar panels and the air purification components. This will help maintain peak performance over time.

CHAPTER-7

CONCLUSION

There are many different kinds of air purifier available in the market with different technologies. Some may have HEPA, carbon, ionizing, UV technology and many more. Some purifiers also contain more than one technology for advanced functioning and better results. Thus, choose the best one matching your requirement and budget. The main function of HEPA Filter is to remove contaminated viruses from the air and provide clean and pure air. Thus, HEPA Filter is a crucial purchase element for the one suffering from dust or pollen allergy. Strict standards have been set for the filters to be classified as HEPA. A HEPA Filter should be able to remove majority percent particles being small as 0.03 microns.

So, buy only a quality product from reliable sources and avoid buying “HEPA-Type” or “HEPA-Like” filters, as these filters will not provide you the best result as compared to the true HEPA Filters. At last, there are many sources from which you can order your HEPA Filter Air Purifier. Why wait for more to avail such luxury home stuff. [Click here](#) if you like to buy the best HEPA Air Purifier.

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