INDUSTRIAL DESIGN PROJECT-3

NEW AGE BUS STOP WITH AIR PURIFIER

Project guide
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Submitted by-
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Approval sheet

This is to certify that the industrial design project entitled “New Age Bus stop with Air Purifier” by Mugdha Dengle is approved for partial fulfillment for the Master of Design degree in Industrial Design.

Approval

Signature of the Project Guide:

Digital Signature
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Signature of the Chair Person:

Signature of the Internal Examiner:

Signature of the External Examiner:

Acknowledgment

I would like to take this opportunity to sincerely express my deepest gratitude to the people who have wholeheartedly supported and helped me achieve success in this project. Firstly i would like to thank my guide Prof. Avinash Shende for his constant feedbacks, invaluable advice and motivation. His guidance and time-to-time inputs gave me a larger perspective to look at.

I would like to give special thanks to my friends
Susovan, Abhishek, and my colleagues for supporting me throughout this project journey. Furthermore, I would like to extend my deepest heartfelt gratitude and love to my family for supporting me through this creative process and help me undertake various academic endeavors that have led me to the place I am today.

Declaration

This written submission is a part of my report, “New Age Bus Stop with Air Purifier” is done as a part of Project - 2 for post-graduation program at IDC, IIT Bombay, under the guidance of Prof. Avinash Shende.
I hereby declare that the thoughts, ideas, and words in this document are original, and appropriate references have been adequately cited wherever due. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or falsified any idea / data / fact / source in my submission.
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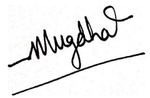

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Abstract

Air pollution has emerged as a pressing concern in urban cities across India, posing a grave threat to the health and well-being of the population. Among those most susceptible are daily commuters who rely on public transport, exposing themselves to harmful pollutants like carbon monoxide, hydroxides, and nitrides, further compromising their well-being.

To combat this issue, a modern bus stop has been developed, integrating advanced air purifiers capable of efficiently eliminating hazardous PM2.5 level particles from the surrounding air. This innovative bus stop design adopts a sustainability-focused approach, aiming to achieve a net-zero carbon footprint by harnessing solar power for electricity generation, thereby minimizing its environmental impact.

Moreover, this cutting-edge bus stop incorporates a range of smart system features to enhance the commuting experience. Supplementary amenities like public Wi-Fi systems, mobile device charging stations, and interactive maps of the surrounding area may also be included to further augment the passenger experience.

Furthermore, this bus stop design prioritizes the promotion of health and wellness. It offers a secure and comfortable environment for commuters, featuring improved lighting and ergonomic seating arrangements. By seamlessly integrating functionality, sustainability, and passenger well-being, this modern bus stop endeavors to address the challenges posed by air pollution while elevating the overall commuting experience for urban dwellers.

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Introduction to Project

Explanation on Sections of the project

This report documents a project that initially focused on gaining an understanding of air pollution, its detrimental effects, and the role of air purifiers in mitigating this issue. The study then progressed to investigate various environments where individuals from diverse backgrounds are most exposed to air pollution, ultimately selecting public transport bus stops as the primary area of interest.
To ensure a comprehensive analysis, this report is structured into three main sections. Section 1 encompasses research studies conducted on air pollution and air purifiers, providing insights into the selection of the final filters and the development of specific project specifications.

Section 2 delves into the examination of different environments, highlighting the decision-making process behind choosing bus stops as the final focus area. It further explores various ideation processes undertaken for each environment studied, ultimately presenting detailed information on the final bus stop design and its specifications. Additionally, this section includes a thorough analysis of dimensions, average bus stop specifications, and considerations for human dimensions to ensure optimal usability and functionality.

Section 3 centers around the design of the final concept. It outlines the progression from the final design brief to the development of a unique design language and extensive ideation processes. Three distinct concepts were thoroughly evaluated, leading to the selection of the most suitable concept. The chosen design presents a modern-day bus stop equipped with innovative air purifying technology, seamlessly integrating filters and efficiently distributing purified air through the roof of the bus stop. The aim is to effectively eliminate hazardous PM2.5 particles from the surrounding air. Furthermore, this environmentally conscious design incorporates solar power to minimize the overall carbon footprint.

By following this structured approach, this report provides a comprehensive overview of the project, offering valuable insights into the research, decision-making processes, and design considerations undertaken to develop an innovative and efficient bus stop with integrated air purification technology.

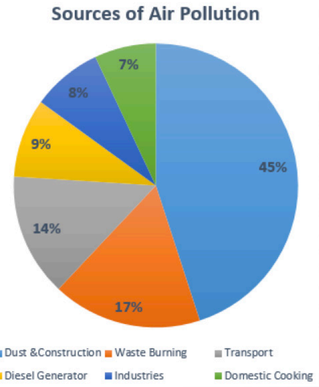
SECTION 1

About air pollution

01. Introduction

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere.
Air pollution refers to the release of pollutants into the air—pollutants which are detrimental to human health and the planet as a whole. According to the World Health Organization (WHO), each year air pollution is responsible for nearly seven million deaths around the globe. Nine out of ten human beings currently breathe air that exceeds the WHO's guideline limits for pollutants, with those living in low- and middle-income countries suffering the most.

Air pollution poses a significant environmental challenge in India, with a notable impact on public health and the overall well-being of its population. The severity of the issue is evident from the fact that in 2019, out of the 30 most polluted cities worldwide, a staggering 21 were located in India. Furthermore, a study based on 2016 data revealed that approximately 140 million people in India were exposed to air quality levels exceeding the World Health Organization's safe limit by at least tenfold. Additionally, 13 out of the top 20 cities with the highest annual levels of air pollution were identified within the country's borders.
Various sources contribute to the alarming levels of air pollution in India, with industrial pollution accounting for 51% of the problem, followed by vehicular emissions at 27%. Crop burning contributes to 17% of the pollution, while other sources make up the remaining 5%. Shockingly, the detrimental effects of air pollution are responsible for approximately 2 million premature deaths in India every year. The emissions originate primarily from vehicles and industrial activities, while rural areas face the additional challenge of biomass burning for cooking and heating purposes. During autumn and spring months, extensive crop residue burning in agricultural fields, employed as a cost-effective alternative to mechanical tilling, emerges as a major source of smoke, smog, and particulate pollution.



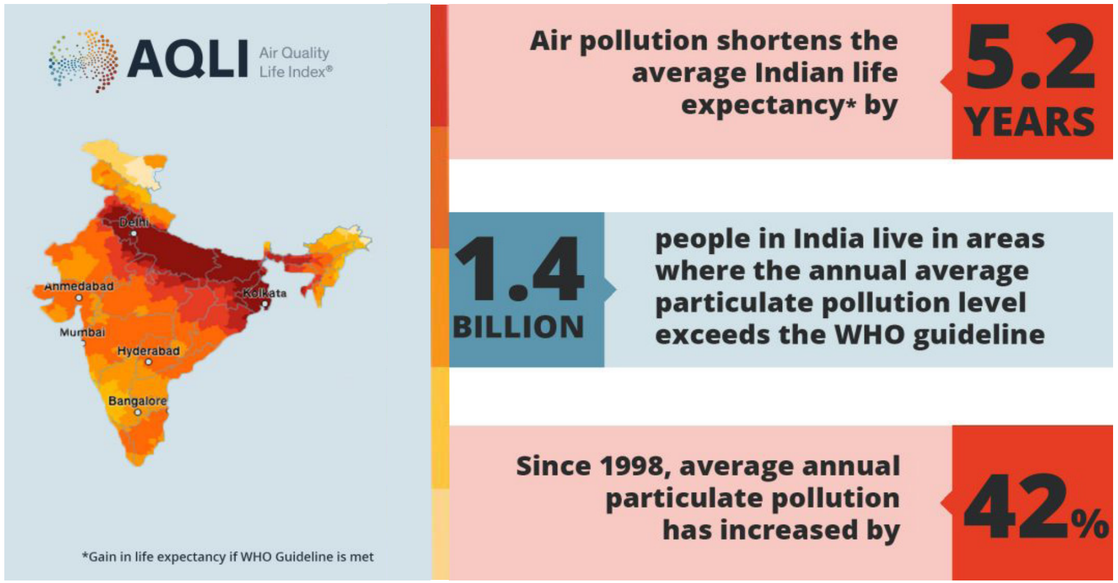
Despite India's relatively low per capita greenhouse gas emissions, the country as a whole ranks as the third-largest producer of greenhouse gases globally, trailing behind China and the United States.
A study conducted in 2013 on non-smokers revealed that Indians exhibit 30% weaker lung function compared to their European counterparts, underscoring the detrimental impact of air pollution on respiratory health.
In an effort to combat the pervasive issue of air pollution, the Air (Prevention and Control of Pollution) Act was enacted in 1981 to regulate air pollution levels. However, the effectiveness of this legislation has been impeded by inadequate enforcement of the associated rules and regulations.
To address the pressing need for improved air quality, the Government of India, in collaboration with IIT Kanpur, introduced the National Air Quality Index in 2015. In 2019, the country launched the National Clean Air Programme, with a preliminary national target aiming for a 20%-30% reduction in concentrations of PM2.5 and PM10 particles by 2024,

using 2017 as the baseline for comparison. This program is set to be implemented in 102 cities that currently surpass the National Ambient Air Quality Standards. Additionally, various initiatives have been undertaken, such as the ambitious construction of The Great Green Wall of Aravalli, an ecological corridor spanning 1,600 kilometers in length and 5 kilometers in width along the Aravalli range from Gujarat to Delhi. This initiative aims to connect with the Shivalik hill range and involves the planting of 1.35 billion (135 crore) native trees over a period of ten years to combat pollution.

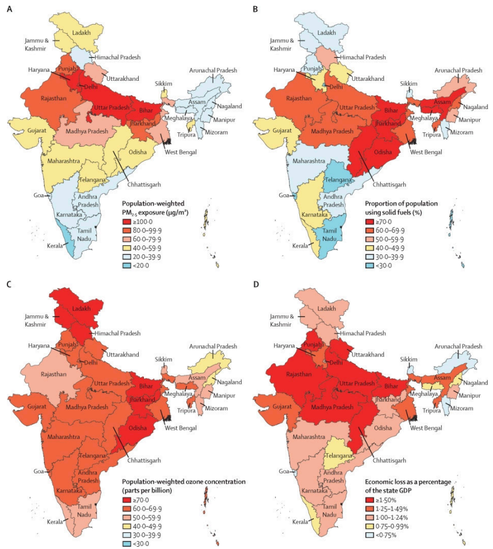
Furthermore, in December 2019, IIT Bombay collaborated with the McKelvey School of Engineering of Washington University in St. Louis to establish the Aerosol and Air Quality Research Facility, dedicated to studying air pollution in India. Notably, a study published in Lancet reported that in 2019 alone, India incurred the devastating cost of nearly 1.67 million deaths and an estimated loss of USD 28.8 billion in terms of economic output as a consequence of worsening air pollution.

These multifaceted efforts and collaborations demonstrate the urgent need to address the air pollution crisis in India comprehensively, with a focus on implementing effective policies, enhancing enforcement measures, and promoting sustainable practices to safeguard the health and well-being of the nation's population while mitigating the economic repercussions of this pressing environmental challenge.

02. Facts of air pollution

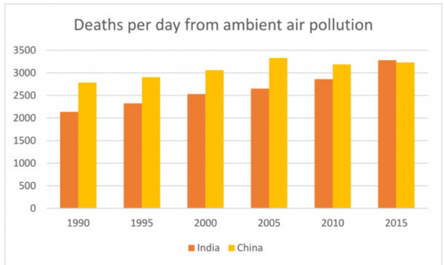


03. Indian statistics



The annual average population-weighted mean PM2·5 concentration (as a measure of ambient particulate matter exposure) was 91·7 µg/m3 (95% uncertainty interval [UI] 69·6–113·9) in India in 2019. Across the states of India, exposure to ambient particulate matter ranged from 15·8 µg/m3 (13·0–18·7), in Kerala, to 217·6 µg/m3 (117·9–297·3), in Delhi—a 13·8 times difference. Higher concentrations were found in the northern states, including the four states with the highest exposures (123·5–217·6 µg/m3; figure 1A; appendix p 18). The proportion of the population using solid fuels for cooking in India in 2019 was 56·3% (55·1–57·4). This proportion was highest in the eastern and northern states, with proportion above 70% in six states (figure 1B; appendix p 18). Use of solid fuels contributed an average 82·8 µg/m3 PM2·5 (41·9–153·8) in households, in addition to the ambient 91·7 µg/m3 PM2·5 present in India in 2019 (appendix p 18). The average ambient ozone concentration in India in 2019 was 66·2 ppb (66·0–66·3), ranging from 47·4 ppb (46·3–48·5), in Arunachal Pradesh, to 76·6 ppb (75·8–77·4), in Jammu & Kashmir and Ladakh (figure 1C).

- There were an estimated 6.5 million deaths worldwide from air pollution-related diseases in 2012, WHO data shows. That's 11.6% of all global deaths – more than the number of people killed by HIV/AIDS, tuberculosis and road injuries combined.
- Another air pollution fact is that it is the fourth-largest threat to human health, behind high blood pressure, dietary risks and smoking.
- The health risks of breathing dirty air include respiratory infections and cardiovascular diseases, stroke, chronic lung disease and lung cancer.
- COVID-19 Lockdown in India significantly improved air quality over many cities.
- Air pollution is causing more deaths in India than in China, according to new research. On average there were 3,283 premature deaths per day in India in 2015 as a result of particulate matter and ozone pollution, compared to 3,233 in China.

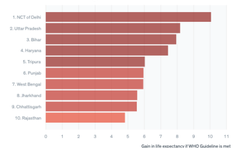


"The temporary air quality improvement achieved by the painful natural experiment of this pandemic has helped demonstrate the importance of reducing emissions from other sectors along with transportation and industry to achieve the national air quality targets in the future."

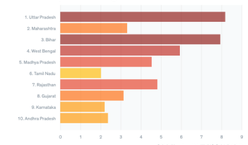
Key take-aways

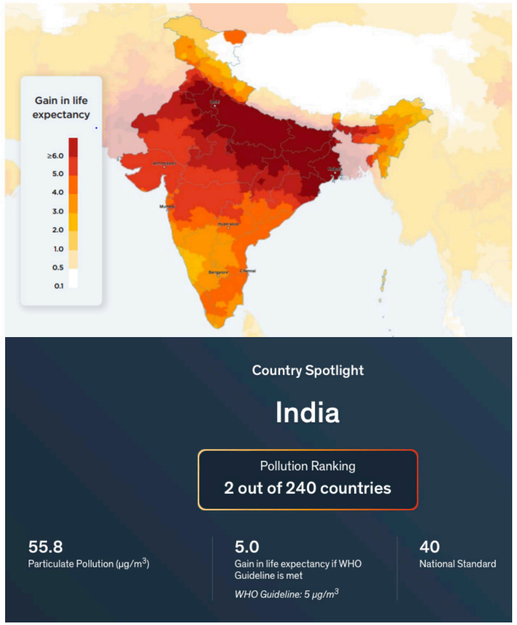
- All of India's 1.4 billion people live in areas where the annual average particulate pollution level exceeds the WHO guideline. Ninety-four percent live in areas where it exceeds India's own air quality standard.
- Particulate pollution has sharply increased over time. Since 1998, average annual particulate pollution has increased 22 percent, cutting 1.3 years off the life of the average resident over those years.
- A quarter of India's population is exposed to pollution levels not seen in any other country, with 248 million residents of northern India on track to lose more than 8 years of life expectancy if pollution levels persist.
- Lucknow, the capital of India's northern state Uttar Pradesh, has the highest level of pollution in the country, with pollution 13 times greater than the WHO guideline. Residents of Lucknow stand to lose 12.1 years of life expectancy if pollution persists.
- India's capital Delhi is also highly polluted. Residents of Delhi could see 13 years added to their lives if pollution were reduced to meet the WHO guideline; 10 years if pollution met India's national standard.

10 Most Polluted Regions



10 Most Populous Regions





04. History

05. Causes

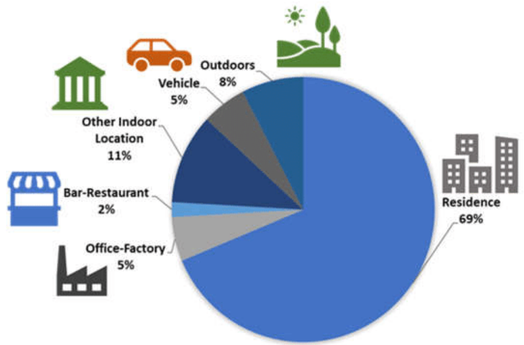
“Most air pollution comes from energy use and production,” says John Walke, director of the Clean Air Project, part of the Climate and Clean Energy program at NRDC. “Burning fossil fuels releases gases and chemicals into the air.” And in an especially destructive feedback loop, air pollution not only contributes to climate change but is also exacerbated by it. “Air pollution in the form of carbon dioxide and methane raises the earth’s temperature,” Walke says. “Another type of air pollution, smog, is then worsened by that increased heat, forming when the weather is warmer and there’s more ultraviolet radiation.” Climate change also increases the production of allergenic air pollutants, including mold (thanks to damp conditions caused by extreme weather and increased flooding) and pollen (due to a longer pollen season).

“We’ve made progress over the last 50 years improving air quality in the United States thanks to the Clean Air Act,” says Kim Knowlton, senior scientist and deputy director of the NRDC Science Center. “But climate change will make it harder in the future to meet pollution standards, which are designed to protect health.”

Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide. Outdoor and indoor air pollution cause respiratory and other diseases and are important sources of morbidity and mortality.

WHO data show that almost all of the global population (99%) breathe air that exceeds WHO guideline limits and contains high levels of pollutants, with low- and middle-income countries suffering from the highest exposures.

Air quality is closely linked to the earth’s climate and ecosystems globally. Many of the drivers of air pollution (i.e. combustion of fossil fuels) are also sources of greenhouse gas emissions. Policies to reduce air pollution, therefore, offer a win-win strategy for both climate and health, lowering the burden of disease attributable to air pollution, as well as contributing to the near- and long-term mitigation of climate change.



06. Effects of Air Pollution

The effects of air pollution on the human body vary depending on the type of pollutant and the length and level of exposure—as well as other factors, including a person's individual health risks and the cumulative impacts of multiple pollutants or stressors. This report focuses on three main categories of air pollutants: smog and soot, hazardous air pollutants, and greenhouse gases.

Smog and Soot:

1.1 Smog:
Smog, also known as ground-level ozone, is formed when emissions from fossil fuel combustion react with sunlight. It is primarily generated by vehicles, factories, power plants, incinerators, and other sources that burn fossil fuels. Smog can cause irritation of the eyes and throat, particularly impacting vulnerable populations such as children, senior citizens, and individuals who spend time outdoors. People with asthma or allergies are at higher risk, as the additional pollutants in smog can worsen their symptoms and trigger asthma attacks.

1.2 Soot:
Soot, or particulate matter, consists of tiny particles of chemicals, soil, smoke, dust, or allergens suspended in the air. It can exist in gas or solid form and is emitted by similar sources as smog. The smallest airborne particles in soot pose a significant health risk, as they can penetrate the lungs and bloodstream. Exposure to fine particulate matter can exacerbate bronchitis, lead to heart attacks, and even contribute to premature death. In 2020, a study by Harvard's T.H. Chan School of Public Health revealed a correlation between long-term exposure to fine particulate matter and higher COVID-19 mortality rates, emphasizing the importance of addressing this environmental justice issue.

Hazardous air pollutants:

A number of air pollutants pose severe health risks and can sometimes be fatal even in small amounts. Almost 200 of them are regulated by law; some of the most common are mercury, lead, dioxins, and benzene. "These are also most often emitted during gas or coal combustion, incinerating, or—in the case of benzene—found in gasoline," Walke says. Benzene, classified as a carcinogen by the EPA, can cause eye, skin, and lung irritation in the short term and blood disorders in the long term. Dioxins, more typically found in food but also present in small amounts in the air, can affect the liver in the short term and harm the immune, nervous, and endocrine systems as well as reproductive functions. Mercury attacks the central nervous system. In large amounts, lead can damage children's brains and kidneys, and even minimal exposure can affect children's IQ and ability to learn.
Another category of toxic compounds, polycyclic aromatic hydrocarbons (PAHs), are by-products of traffic exhaust and wildfire smoke. In large amounts they have been linked to eye and lung irritation, blood and liver issues, and even cancer. In one study, the children of mothers exposed to PAHs during pregnancy showed slower brain-processing speeds and more pronounced symptoms of ADHD.

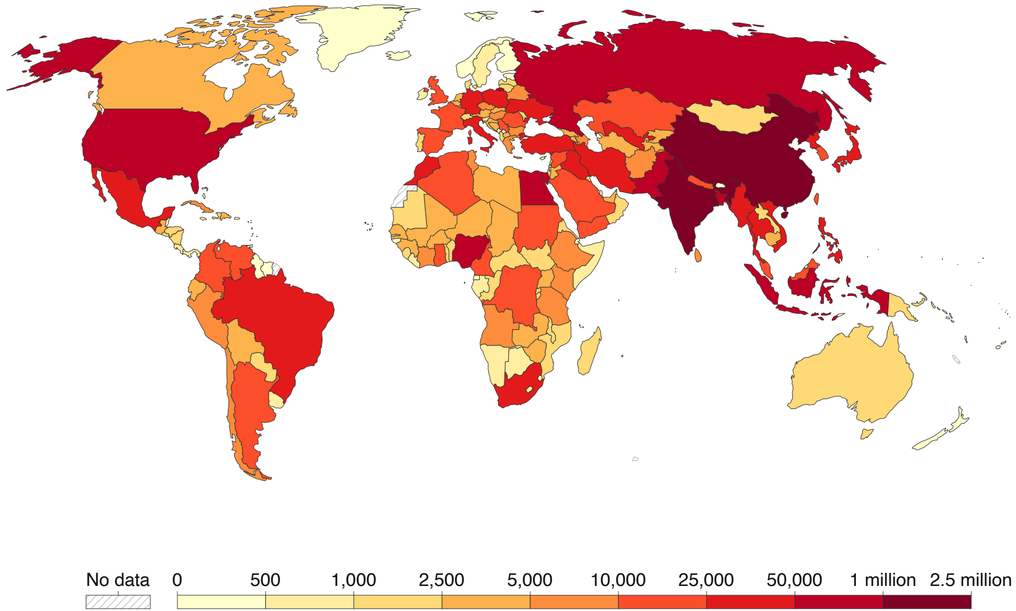
Greenhouse gases:

By trapping the earth's heat in the atmosphere, greenhouse gases lead to warmer temperatures, which in turn lead to the hallmarks of climate change: rising sea levels, more extreme weather, heat-related deaths, and the increased transmission of infectious diseases. In 2018 carbon dioxide accounted for 81 percent of the country's total greenhouse gas emissions, and methane made up 10 percent. "Carbon dioxide comes from combusting fossil fuels, and methane comes from natural and industrial sources, including large amounts that are released during oil and gas drilling," Walke says. "We emit far larger amounts of carbon dioxide, but methane is significantly more potent, so it's also very destructive." Another class of greenhouse gases, hydro-fluorocarbons (HFCs), are thousands of times more powerful than carbon dioxide in their ability to trap heat. In October 2016 more than 140 countries reached an agreement to reduce the use of these chemicals—which are found in air conditioners and refrigerators—and develop greener alternatives over time. Though President Trump was unwilling to sign on to this agreement, a bipartisan group of senators overrode his objections in 2020 and set the United States on track to slash HFCs by 85 percent by 2035. According to David Doniger, senior strategic director of NRDC's Climate and Clean Energy program, "the agreed-to HFC phasedown will avoid the equivalent of more than 80 billion tons of carbon dioxide over the next 35 years."

Pollen and mold:

Mold and allergens from trees, weeds, and grass are also carried in the air, are exacerbated by climate change, and can be hazardous to health. Though they aren't regulated and are less directly connected to human actions, they can be considered a form of air pollution. "When homes, schools, or businesses get water damage, mold can grow and can produce allergenic airborne pollutants," Knowlton says. "Mold exposure can precipitate asthma attacks or an allergic response, and some molds can even produce toxins that would be dangerous for anyone to inhale."
Pollen allergies are worsening because of climate change. "Lab and field studies are showing that pollen-producing plants—especially ragweed—grow larger and produce more pollen when you increase the amount of carbon dioxide that they grow in," Knowlton says. "Climate change also extends the pollen production season, and some studies are beginning to suggest that ragweed pollen itself might be becoming a more potent allergen." If so, more people will suffer runny noses, fevers, itchy eyes, and other symptoms.
Air pollution is now the world's fourth-largest risk factor for early death. According to the most recent State of Global Air report—which summarizes the latest scientific understanding of air pollution around the world—4.5 million deaths were linked to outdoor air pollution exposures in 2019, and another 2.2 million deaths were caused by indoor air pollution. "Despite improvements in reducing global average mortality rates from air pollution, the world's most populous countries, India and China, continue to bear the highest burdens of disease," says Vijay Lamaye, staff scientist at the NRDC Science Center. "This report is a sobering reminder that the climate crisis threatens to worsen air pollution problems significantly if we fail to act to cut carbon pollution."

Deaths from outdoor air pollution, 2019



07. Effects on Health

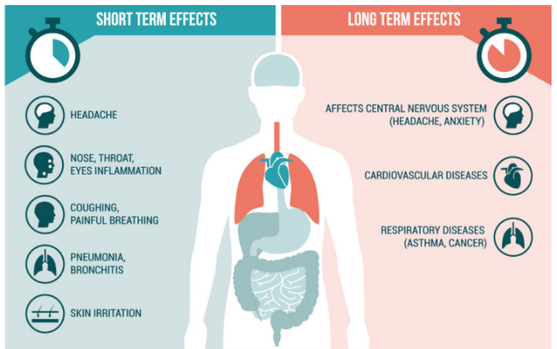
Long-term exposure to polluted air can have permanent health effects such as:

Accelerated aging of the lungs

Loss of lung capacity and decreased lung function

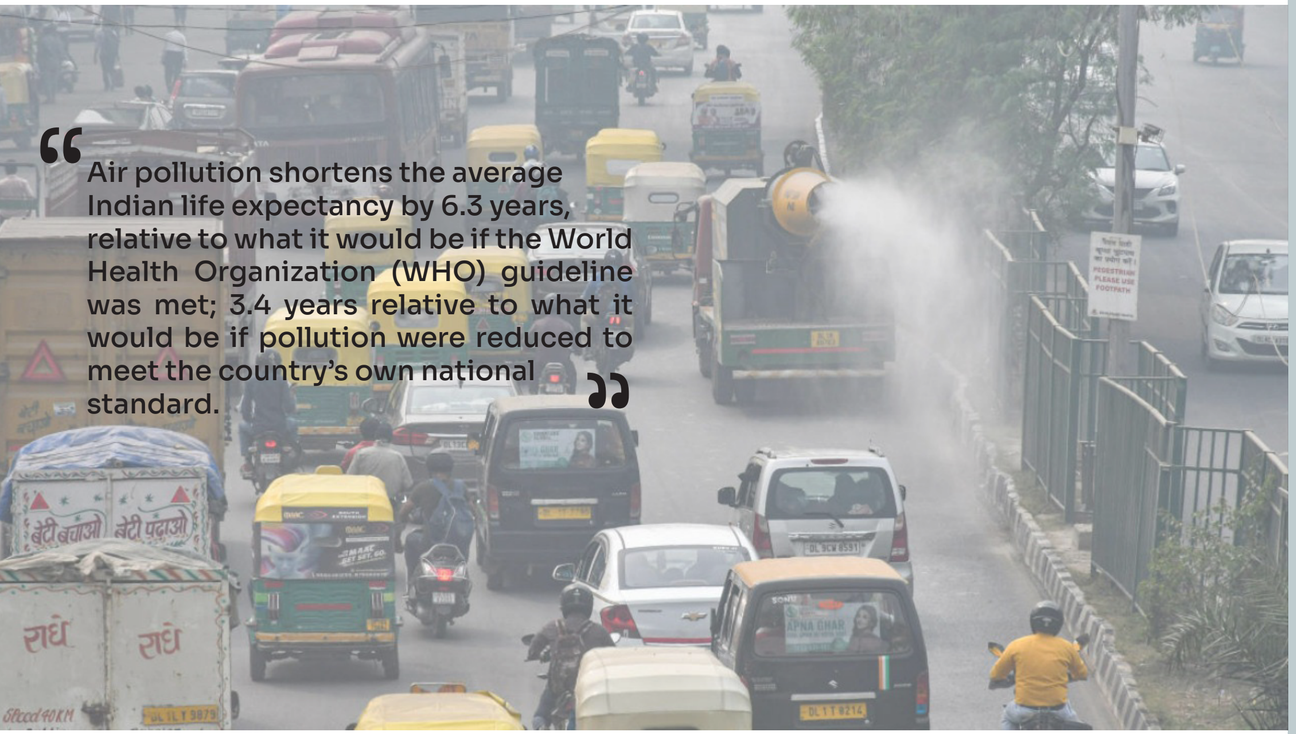
Development of diseases such as asthma, bronchitis, emphysema, and possibly cancer

Shortened life span



Those most susceptible to severe health problems from air pollution are:

- Individuals with heart disease, coronary artery disease or congestive heart failure
- Individuals with lung diseases such as asthma, emphysema or chronic obstructive pulmonary disease (COPD)
- Pregnant women
- Outdoor workers
- Older adults and the elderly
- Children under age 14
- Athletes who exercise vigorously outdoors



> Air pollution shortens the average Indian life expectancy by 6.3 years, relative to what it would be if the World Health Organization (WHO) guideline was met; 3.4 years relative to what it would be if pollution were reduced to meet the country's own national standard.

Particulate size

On the other end of the spectrum, pollen, salt, and sand are significantly larger than viruses or bacteria. Because of their higher relative sizes, our body is usually able to block them out.

Chemicals from coal power plants or automobile exhaust can react with water vapor in the atmosphere and sunlight to form new particles or compounds, and these particles can be under 2.5 microns in size.

The current PM2. 5 concentration in India is 11.6 times above the recommended limit given by the WHO 24 hrs air quality guidelines value.

To understand the working of filters sizes of the particles were also looked at for a better understanding.

Particles	Average Size (microns, µm)
Zika virus	45nm
T4 Bacteriophage	225nm
Coronavirus COVID-19 (SARS-CoV-2)	0.1-0.5µm
Bacterium	1-3µm
Light dust particle	1µm
Dust particle: PM2.5	≤2.5µm
Respiratory droplets containing COVID-19	5-10 µm
Red blood cell	7-8 µm
Dust particle: PM10	≤10µm
Pollen grain	15µm
White blood cell	25µm
Visibility threshold (what the naked eye can see)	10-40 µm
Grain of salt	60 µm
Fine beach sand	90 µm
Human hair	50-180 µm

Not Filterable Partially Filterable Fully Filterable

fig. 10 Range of particle sizes in nature

On the other end of the spectrum, pollen, salt, and sand are significantly larger than viruses or bacteria. Because of their higher relative sizes, our body is usually able to block them out—a particle needs to be smaller than 10 microns before it can be inhaled into your respiratory tract. Because of this, pollen or sand typically get trapped in the nose and throat before they enter our lungs. The smaller particles, however, are able to slip through more easily.

When there are many different types of air pollutants, why do we focus on PM 2.5? Why is it particularly dangerous?

A chemically charged pollutant, PM has contributions from all the primary emissions. The tiny particles, known as PM2.5, have a diameter of less than 2.5 micrometers and can penetrate deep into the lungs and cardiovascular system, increasing the risk of disease.

Black carbon and organic carbon, as primary emissions are part of PM 2.5

SO2 undergoes chemical reactions to form sulphate aerosols, which is part of PM 2.5

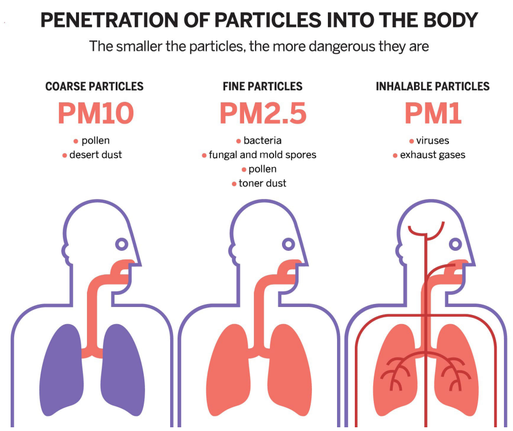
NOx-CO-VOC combine and react in many ways to chemically transform to form nitrate and secondary organic aerosols, which are part of PM2.5

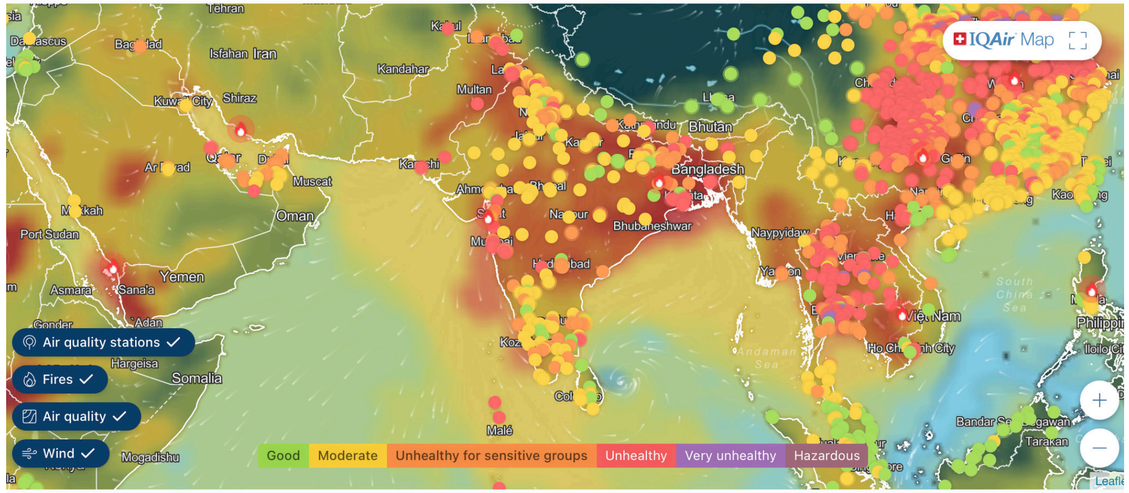
NOx-CO-VOC also combine and react in many ways to form and consume ozone (depending on the mixture of the gases), which also contributes to health impacts and also participates in the formation of nitrates and secondary organic aerosols, which are part of PM 2.5

So, if we target PM 2.5, the one pollutant we are mainly concerned about in India, we are invariably targeting all the other pollutants as well.

Therefore, any control mechanism aimed to reducing direct PM 2.5 emissions also reduces other pollutants (since sources to all these pollutants are common), except for resuspended dust.

The particle size, less than 2.5 micro-meter, is small enough to enter our lungs and blood stream, and stay there for a long time. There are more studies linking PM 2.5 to various health risks than any of the other pollutants.



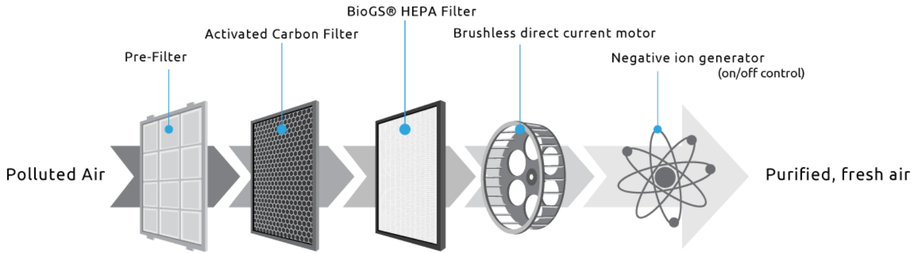


Air purifying techniques

There are two types of air purifying technologies, **active** and **passive**. Active air purifiers release negatively charged ions into the air, causing pollutants to stick to surfaces, while passive air purification units use air filters to remove pollutants. Passive purifiers are more efficient since all the dust and particulate matter is permanently removed from the air and collected in the filters.[13] Several different processes of varying effectiveness can be used to purify air. As of 2005, the most common methods were high-efficiency particulate air (HEPA) filters and ultraviolet germicidal irradiation (UVGI).

Air filter purification traps airborne particles by size exclusion. Air is forced through a filter and particles are physically captured by the filter. Various filters exist notably including:

- High-efficiency particulate air filter (HEPA)
- Ionizers and Ozone Generators
- Electrostatic
- Carbon Filters
- Ozone
- Pre filters
- UV Light
- Titanium Dioxide
- Negative Ions
- Gas Chamber
- Water



Types of air filtration techniques

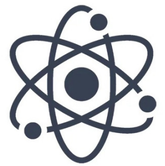
High-efficiency particulate air filter (HEPA)

HEPA filters, which stand for High-Efficiency Particulate Air filters, are composed of incredibly fine glass threads that possess a diameter of less than 1 micron. To put this into perspective, a human hair measures approximately 75 microns in diameter, highlighting the minuscule size of these threads. These delicate glass threads are meticulously entangled and compressed, forming a dense filter mat. Due to the minute size of each individual thread, the majority of the filter mat actually comprises air. The openings or pores within the mat are exceptionally diminutive, typically measuring less than 0.5 micron in size. Notably, HEPA filters possess the capacity to effectively trap particles as small as 0.3 microns in diameter, showcasing their remarkable filtration capabilities. Although the physical width of a HEPA filter may only be around 0.10 inches or 2.5 millimeters, it is astonishing to consider that it comprises an intricate arrangement of approximately 2,500 layers of these fine glass threads.

HEPA / Mechanical Filtration

Ionizers and Ozone Generators

Despite the slight variation in the molecules they produce, ionizers and ozone generators function in a strikingly similar manner. Both of these devices generate either ions or ozone, both of which possess an electric charge. Conversely, the particles commonly present in the air maintain a neutral charge. However, upon encountering the ions or ozone generated by these devices, the particles acquire an electric charge as well. As a result, instead of remaining suspended in the air, these charged particles adhere to surfaces within the room.
It is important to note that individuals, particularly those with respiratory conditions, may experience irritation in their lungs due to the presence of ozone in the air.



Ionization

Electrostatic Filters

Electrostatic filters are made up of two sections—the ionising section consists of wires where airborne particles in the air are given a positive charge when they pass through, and the collection section, where these positively charged particles are attached to negatively charged collection plates, removing them from the air. They work by creating a cloud of free electrons through which dust particles are forced to pass. As the dust particles pass through the plasma, they become charged, making them easy to collect. Electrostatic precipitators can collect particles down to a diameter of 0.01 microns (0.00001 mm).

Activated Carbon Filters

Neither HEPA filters nor electrostatic precipitators can remove volatile organic compounds from the air, therefore do nothing to reduce odors. For this reason, most air purifiers are equipped with a pre- or post-filter composed of activated carbon.
Activated carbon is produced by heating a carbon source (coconut shells, old tires, bones, etc.) at very high temperatures in the absence of oxygen, a process also known as pyrolysis or destructive distillation. Pyrolysis separates the pure carbon from the other materials contained in the raw material. The pure carbon is then exposed to steam at 800°C (1,500°F). The high temperature steam activates the carbon. The activation process forms millions of cracks in the carbon grains. These cracks have diameters of about 0.002 microns (0.000002 mm). Because there are so many cracks, the activation process provides the carbon with an enormous surface
area per weight—about 1,000 m 2 /g. The millions of cracks provide locations where organic compounds can be adsorbed. In addition, the surface of the carbon carries a residual electrical charge that attracts non-polar chemicals (chemicals that do not have separated positive and negative charges) to it. Activated carbon is very effective at adsorbing odor producing compounds.

Activated Carbon

Ozone

Ozone

Ozone air purifiers essentially take in oxygen from the air (O2) and give it a strong electrical charge. This electrical charge allows the oxygen molecules to rearrange themselves and form O3, our famous ozone.

Now, the ozone is released from the machine into the air. When it hits molecules like mold or smoke, the third oxygen molecule attaches itself to molecules of the pollutant and basically eliminates it.
The O3 attaches itself to bacteria, fungus, germs, odors, and other contaminants and, at the molecular level, destroys the cell wall. This process eliminates the contaminant while reverting the ozone back to oxygen.

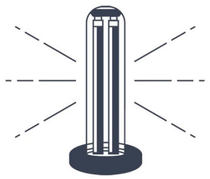
Through this process, ozone generators can be extremely useful for cleaning pungent odors, removing the smell of smoke, and eliminating mold. They are used in hospitals, hotels, and even homes, but, as we'll learn, they can be dangerous and must be used only by trained, qualified professionals.

Pre filters

Prefilters are also known as layers filters or double filters in an air purifier. This filter works as a barrier to stop the larger particles to enter the main filter. As a result, the purifier filter maintains the longevity of the main filter also. Basically, it decreases the load on the internal filter of the air purifier. The best thing about this filter is it reduces the cost of the replacement or any kind of repair. It stops the large debris, hair furs, dust and pollen and increases the lifespan and capacity of the main filter. You can wash and reuse these filters again and again.

Ultraviolet Light Filters

Ultraviolet light filters are not only the filters but the destroyers to destroy the bacteria using ultraviolet light. These filters kill the bacteria, molds, viruses, and yeasts from the indoor air. These filters are ideal to use for patients suffering from longterm sickness and useful in hospitals to prevent diseases due to infections.
The ultraviolet light filters are unable to remove the solid particles, allergens, and dust from the air. But they remove the cigarette smoke, chemical fumes, and bad odor from the indoor air effectively.



UV Light

Titanium Dioxide

Titanium dioxide (TiO2) technology employs the use of nano particles of TiO2, combined with calcium carbonate to counteract any acidic gases that might be present, cleverly integrated into a slightly porous paint medium. This innovative approach harnesses the power of photo-catalysis to initiate the decomposition of airborne contaminants right at the surface where it is applied.
An intriguing application of Titanium Dioxide (TiO2) technology lies within specialized filters that capitalize on the process of photo-catalysis to effectively break down organic compounds, including volatile organic compounds (VOCs), through oxidation. These advanced filters are skillfully coated with the photo-catalyst, TiO2, which exhibits a remarkable reaction when exposed to light, resulting in the formation of oxygen radicals. These highly reactive oxygen radicals then undergo a transformative reaction with organic compounds, effectively destroying them and effectively eliminating any unpleasant odors that may be present in the surrounding air.
However, it is important to note that while bacteria and viruses are also considered organic entities, an extensive study has demonstrated that TiO2 has limited germicidal capabilities when it comes to eradicating airborne pathogens.

Benchmarking

The benchmarking of Air purifier was done on the below mentioned parameters:

- Type of Air Purifier
- The range(Area Covered)
- **Power input**
- **No. of filters present**
- **Size and efficient use of space**
- Weight
- Regulations if any
- Price
- **Design Language**
- Pros and Cons

CADR
CADR, the Clean Air Delivery Rate, is a metric that was developed as a way of measuring the performance of residential air purifiers. The CADR rating reflects the volume of air in CFM (cubic feet per minute) that is cleaned of particles of certain sizes.
to Calculate, CADR=Area of Room/1.55

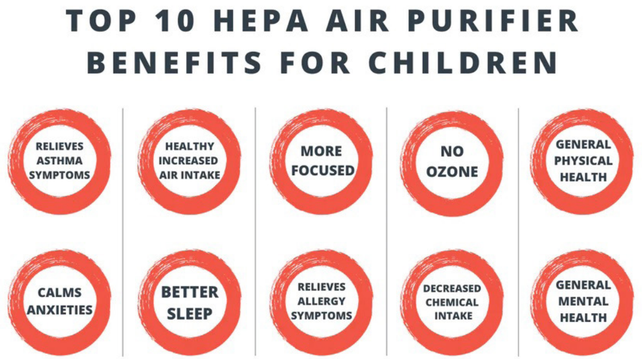
Health Benefits Of The Air Filters

Like the AC filters, the air filters in an air purifier also plays a major role in the benefits of your health. Let's have a look at them in brief.

The higher MERV rated filters are efficient to capture the mold spores, bacteria, and small particles. As a result, they are beneficial to people have asthma and allergic to mold.

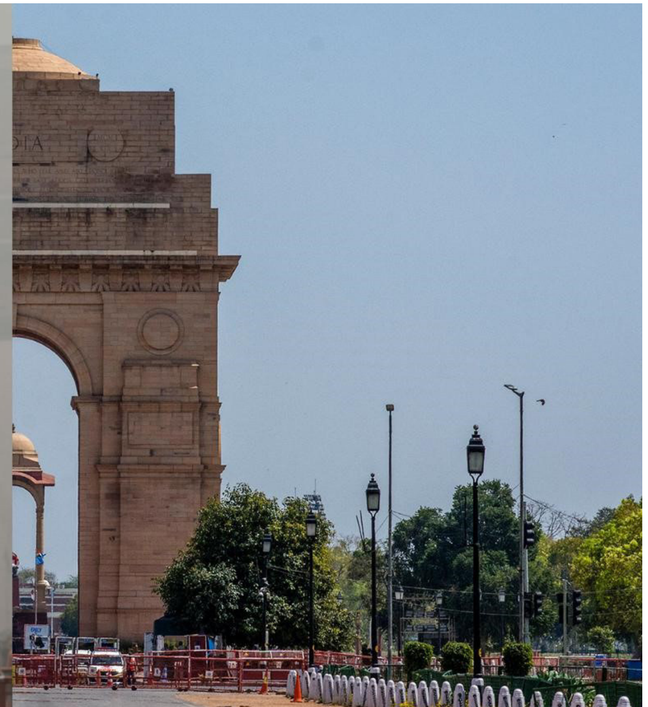
These filters are able to trap viruses and bacteria that cause respiratory infections in people.

Dusta and molds are the major cause of Asthma in people and these filters are largely beneficial for them.

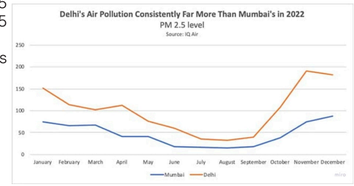


Delhi Visit

Delhi city has a major air pollution problem. This project will be incomplete without going there and getting first hand experience. This visit helped me to understand the ground reality and begin this project journey.



Delhi's air pollution level has been higher than Mumbai's every month in 2022. And it's not just recent months. For the past four years, Delhi's annual average of PM 2.5 has been an average of 95 microgram per cubic meter, whereas Mumbai's has been 45.



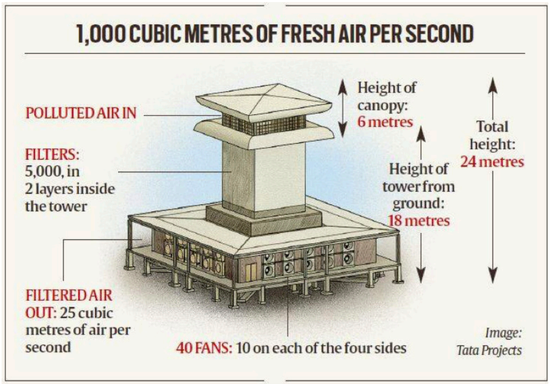
In an effort to address the pressing issue of air pollution, the government has undertaken various initiatives on multiple fronts. One significant measure has been the prohibition of stubble burning in neighboring states, recognizing its detrimental impact on air quality. Additionally, numerous installations of outdoor air purifiers have been implemented as part of the comprehensive strategy to combat pollution. Considering the importance of studying these installations and their effectiveness, it became essential to conduct a visit to Delhi. By exploring these initiatives firsthand, valuable insights can be gained regarding their implementation, functionality, and potential contribution to improving the air quality in the region. This on-site assessment provided a comprehensive understanding of the measures taken and their implications, enabling informed decision-making and the formulation of more targeted strategies to combat air pollution effectively.

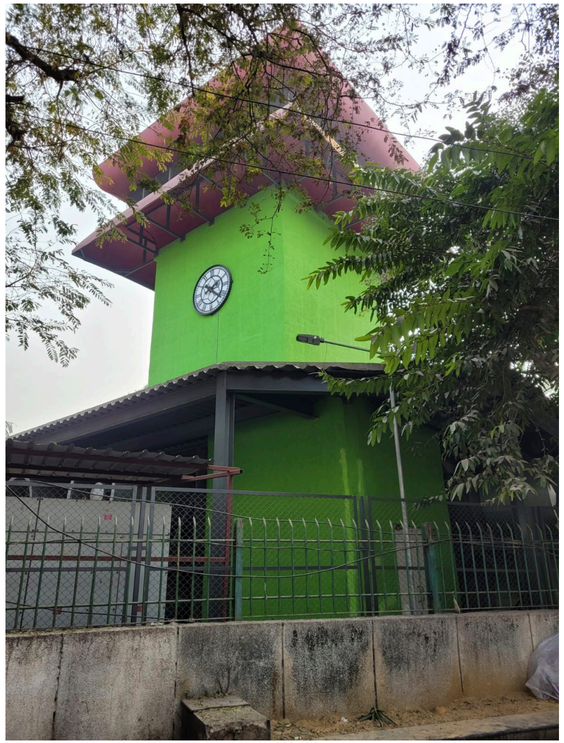
"For last November and December, Delhi exceeded the WHO's safe air quality standard by almost 40 times."

Smoke tower at CP

These towers have been built by Tata Projects Limited (TPL), with technical assistance from IIT Bombay and in collaboration with IIT Delhi and Central Pollution Control Board (CPCB).

During Diwali this tower recorded a PM2.5 concentration of 642 micrograms per cubic metre at the inlet and 453 micrograms per cubic metre at the outlet.





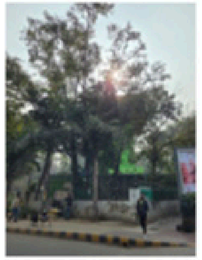
Having 40 fan units

Using too much electricity

High maintenance

Using 5,000 HEPA filters at top of tower

Many personals required to manage



Takes up alot of area

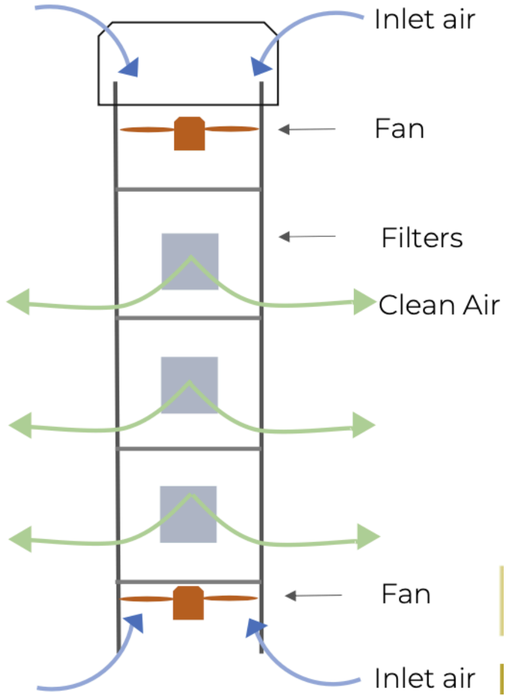
Require additional security for the premises

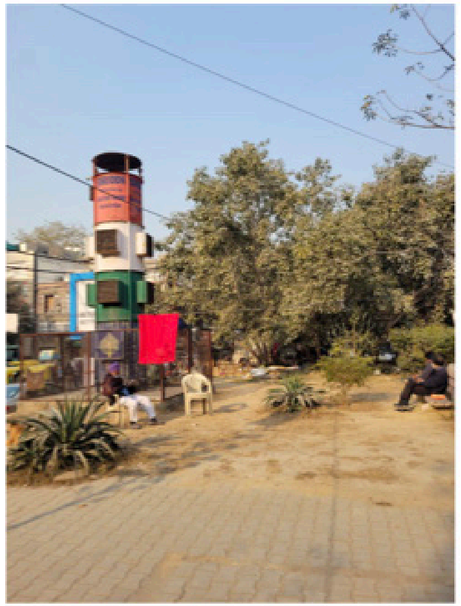
Smog tower at Lajpat Nagar

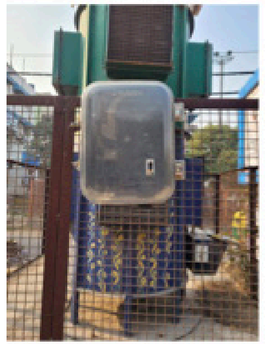
Primarily it has three HEPA filter mounted on the duct. The design is a bit modular and you can increase the capacity by stacking more ducts.

Pros:

- 60,000 cubic meter of clean air
- Range of 500 to 700 meters
- A modular design
- Robust installation made of steel





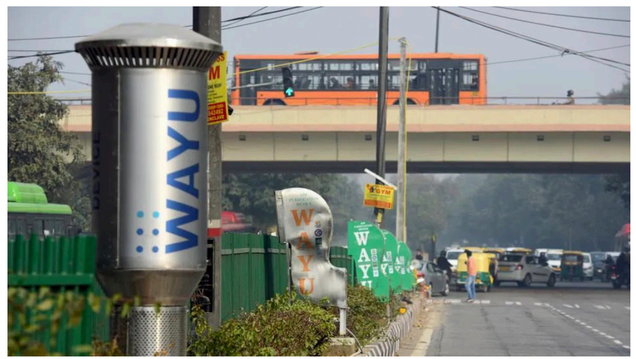


WAYU (Wind Augmentation Purifying Unit) air purifiers

- It has been indigenously developed by the Council of Scientific and Industrial Research - National Environmental Engineering Research Institute (CSIR-NEERI).
- It comprises a fan that sucks in air and removes dust and particulate matter.
- The carbon monoxide and hydrocarbons are oxidized into less harmful carbon dioxide using activated carbon coated with titanium dioxide.
- More than 70 such WAYU machines were installed last year at some of the most polluted road intersections such as ITO, Anand Vihar, Wazirpur Chowk, Shadipur and Bhikaji Cama.

The filters get chocked within 3 days and proper maintenance has not been carried out. Constant monitoring required.

The newer models of WAYU purifiers.



Design Directions

- Versatile use
- Tamper proof
- Functionality
- Aesthetics
- Manufacturing
- Maintenance
- Installation

Primary Research Overview

Robust design

The outdoor air purifier should have ability to tackle any harsh weather conditions of cities of India. Public abuse and general wear and tear should also be considered.

Capacity of purifier

Government is investing heavily on air quality monitoring. Using the data currently available can help us coming up more ways to tackle the problem

Placement of product

The placement of outdoor air purifiers is crucial so that it provides direct air flow to the surrounding areas. Also it impacts maximum area. Many people get benefitted by this at the same time.

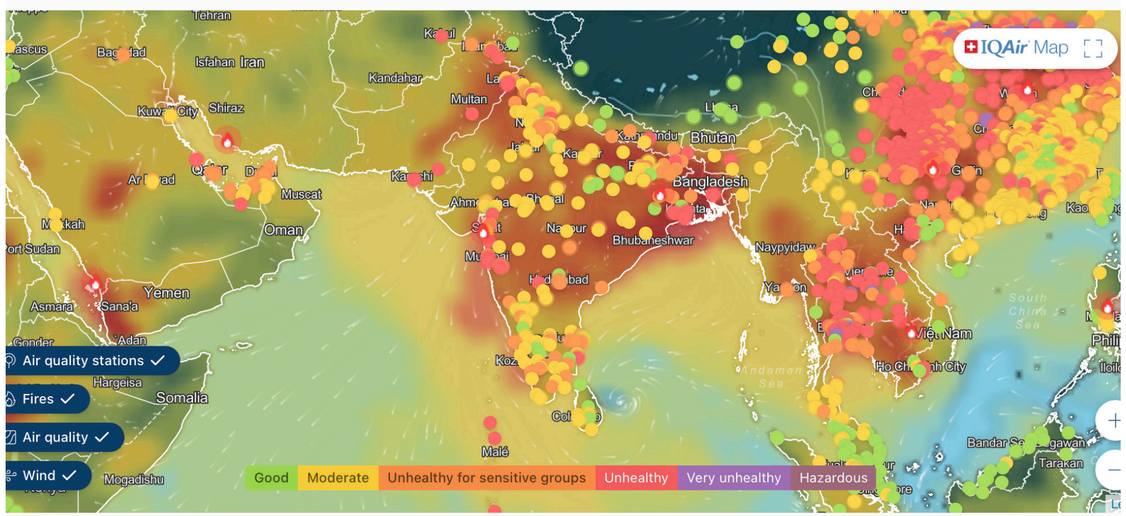
Tamper proof design

The currently installed wayu purifiers are not tamper proof. Anyone can break into these installations with ease and even steal the parts. This needs changes in design.

Maintenance

The outdoor air purifier should require minimum quality maintenance and monitoring. Proper training is required of the current designs. They are getting choked in 3 days and require cleaning filters often.

Current AQI in India



Narrowed to Mumbai city

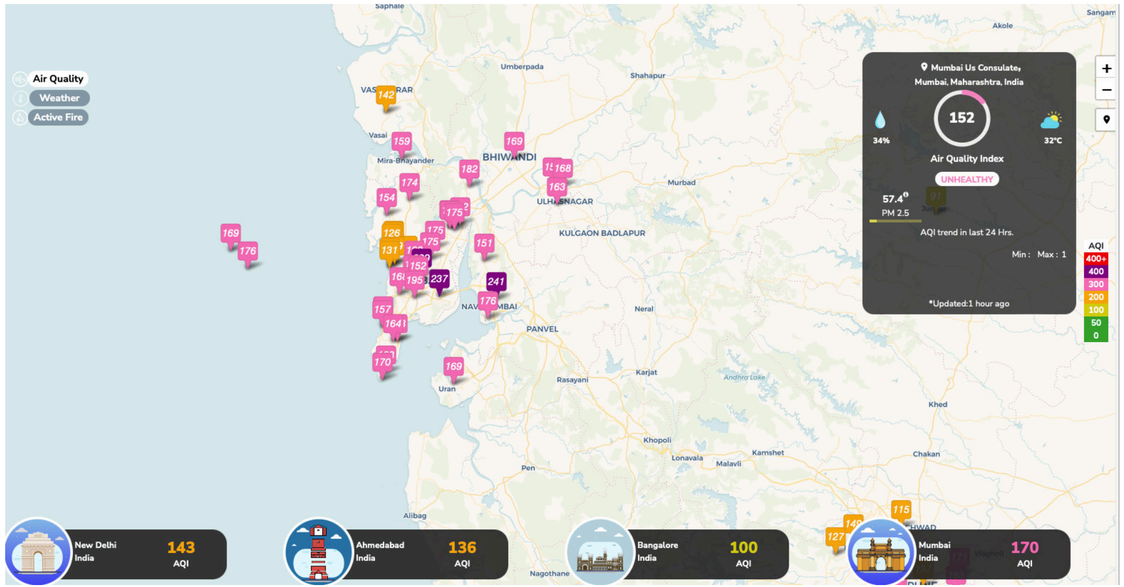
MUMBAI'S AIR POLLUTION UP 18% IN NOVEMBER AND DECEMBER, 2022

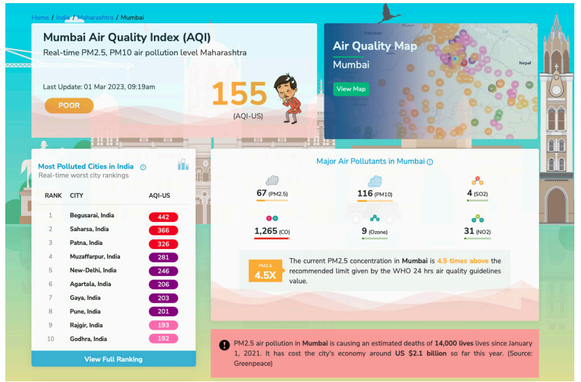
PM 2.5 LEVEL

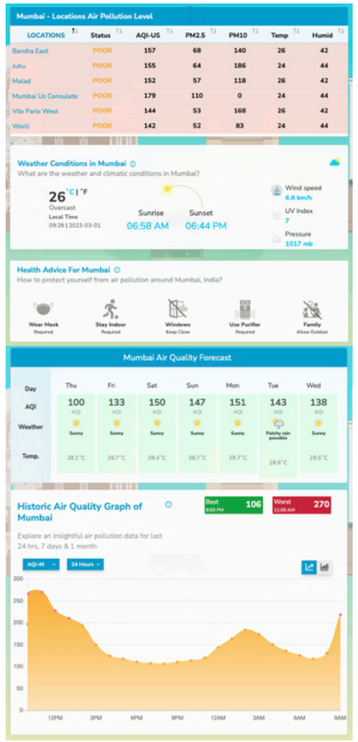
	NOVEMBER	DECEMBER
2019	57.7	81.1
2020	63.8	70.6
2021	63.3	74.6
2022	74.8	88.1

Source: IQ Air

AQI Levels in Mumbai Currently are highest in India







Secondary research

News Articles

indianexpress.com

Atmospheric pollution increasing in rural India, say IIT-KGP researchers

The researchers found that air pollution is not typically an urban phenomenon but can affect the environment in rural pockets also.

indianexpress.com

Why Mumbai's air became worse than Delhi's - and what can be done

The reason for the sudden spike in the current pollution cycle in Mumbai is part of a larger meteorological phenomenon that needs to be studied further

Delhi hospitals witnesses surge in respiratory, cardiac problems amid cold wave, air pollution: Docs

Air pollution speeds up bone loss from osteoporosis: Study

Mumbai ranked 'world's 2nd most polluted city' in the global Air Quality

Delhi air pollution: Relief for Delhiites as AQI improves to 'poor' from 'very poor' category

Mumbai's air quality again in 'poor' category; could be worst in January in last 5 years

Notable dip in Delhi air pollution levels in 2022-23 winter due to GRAP implementation of 13-point action plan, GRAP: Raj

Delhi records maximum temperature of 23.3 deg C

Study suggests brief exposure to air pollution has rapid impacts on brain

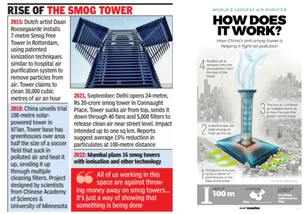
Mask up, limit outdoor activities to keep kids safe amid poor AQI: Doctors - Times of India

Delhi schools closed after air quality worsens, to reopen from Wednesday | Delhi News - Times of India

Delhi's AQI slips to 'very poor' category again: Those with chronic issues should wear masks & use air-purifiers, say doctors - Times of India

'Limit outdoor workouts, opt for HIIT training indoors,' advise experts amid NCR's poor AQI | Delhi News - Times of India

Study of outdoor air purifiers shows they cut PM2.5 by 17% | Gurgaon News - Times of India



RISE OF THE SMOG TOWER

2015: Dutch artist Daan Roosegaarde installs 7-metre Smog Free Tower in Rotterdam, using patented ionization techniques similar to hospital air purification system to remove particles from air. Tower claims to clean 30,000 cubic metres of air an hour

2018: China unveils 60m 100-metre solar-powered tower in Xi'an. Tower base has greenhouses over area half the size of a soccer field that suck in polluted air and heat it up, sending it up through multiple cleaning filters. Project designed by scientists from Chinese Academy of Sciences & University of Minnesota

2021, September: Delhi opens 24-metre, Rs 20-crore smog tower in Connaught Place. Tower sucks air from top, sends it down through 40 fans and 5,000 filters to release clean air near street level. Impact intended up to one sq km. Reports suggest average 15% reduction in particulates at 100-metre distance

2022: Mumbai plans 16 smog towers with kwikselton and other technology

All of us working in this space are against throwing money away on smog towers... It's just a way of showing that something is being done

WORLD'S LARGEST AIR PURIFIER

HOW DOES IT WORK?

How China's anti-smog tower is helping it fight air pollution

100 m

[LANCET STUDY] DISEASE BURDEN ESTIMATE UPDATE

Bad air caused over 6.6 mn premature deaths in 2019; India hardest hit with 1.6 mn fatalities

Rhythma Kaul

letters@hindustantimes.com

NEW DELHI: More than 6.6 million people died due to air pollution in 2019, a new study published on Tuesday estimated, with India contributing the highest share at 1.67 million, or 17.8% of such premature deaths.

Overall, according to a study in the Lancet Planetary Health, nine million people died to pollution, a number unchanged since the last analysis in 2015. The nine million fatalities represent one in six deaths worldwide.

Water pollution was responsible for 1.36 million premature deaths, lead exposure leading to another 900,000 and toxic occupational hazards added a further 870,000 premature deaths, the report said.

Ambient air pollution, which refers to air in normal circumstances, was responsible for 4.5 million deaths in 2019, up from 4.2 million deaths in 2015 and 2.9 million in 2000.

The report mentions that India made efforts against household air pollution, most notably through the Pradhan Mantri Ujjwala Yojana programme, but still had the world's largest estimated number of air pollution related deaths.

"India has developed instruments and regulatory powers to mitigate pollution sources but there is no centralised system to drive pollution control efforts and achieve substantial im ments. In 93% of Ind amount of pollution re well above WHO guidelin µg/m3," it said.

According to the rep pollution is most severe Indo-Gangetic Plain, topography and meteorol centrate pollution from a mobility, industry, agric and other activities. Bur biomass in households w single largest cause of air tion deaths in India, follo

AIR WE BREATHE

continued

Negative criticism against outdoor air purifiers

Beyond the ribbon-cutting, the media coverage, and the quick pat on the back for admirable attempts, one would find outdoor air purification projects to be an absolute waste of the taxpayer money, more so in a poor country like India.

Instead of focusing on the root cause and tackling the issues at source, the cost of installation, maintenance, electricity consumption, and carbon footprint for the non-useful gimmick is an injustice to the already suffering public.

Though these devices might seem fancy and useful on appearance, we must not fool ourselves with these band-aid solutions and aim our efforts and resources at the root cause, various emissions sources, the system design issues of transparency, accountability, and better environmental monitoring.

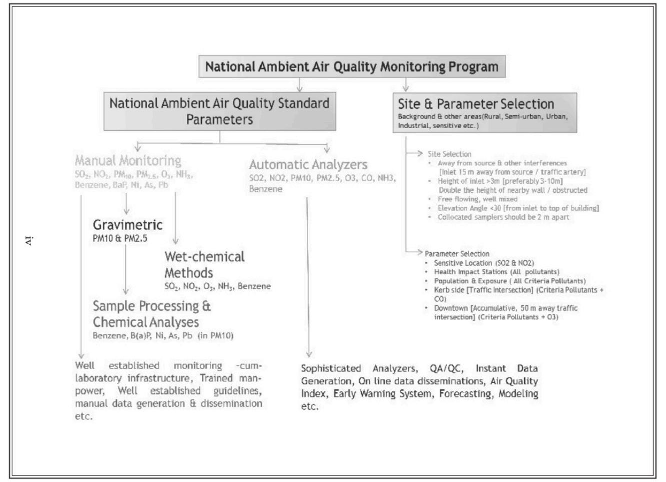
With a targeted focus on managing industrial emission through better filtration equipment, removal of polluting poor-quality vehicles from streets, and building sustainable public transport, waste management,

What we are most worried about is their ability to take conversation surrounding air pollution away from “reducing and cutting down on sources of air pollution” and replacing it with “learning to live with air pollution”. This is a subtle, yet dangerous shift in mindset which can really impact our ability to combat and reduce air pollution.

Installing Outdoor Air Purifiers to solve Air Pollution is like putting Air Conditioners to solve Global Warming.

What is encouraging, however, is that this step shows that governments are indeed willing to combat air pollution and more importantly, are willing to invest in possible solutions. What we as citizens can do, is to ensure that governments act responsibly to address the climate crisis that is going to inevitably arrive.

Documents study



Design of Solar Powered Air Purifier with Air Quality Monitoring

Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 8, July 2021: 298-306

Design of Solar Powered Air Purifier with Air Quality Monitoring

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Abstract

This paper is regarding planning and making out an air setup system with quality check of the air at any place. It uses an extra high power energy resource for checking the efficiency of the system which reduces pollution in and outside. The air consists of many suspended particulates to be extracted. This is done in the basis of per area particulate method even in the key particulate contributing area such as urban areas and industrial areas. It deals with a nonconventional procedure and purposes to achieve absolute best air filtration results exploitation eco-accommodating and efficient method. It chips away at the major guideline of grip of the suspended particles inside the air with the fluid and settles down on account of being heavier than air and gets isolated from the air serving to United States to accomplish higher air quality index. The turbine runs in a way to collect the impurities in the region and splits them to a separate channel with the help of power radiation intensity using panels.

Keywords: AQI, impurities, precipitate, moisture air content

1. Introduction

Nowdays, pollution in any form makes the world to be in a challenging situation. And it is high in metro cities. The majority of contamination comes as result from vehicle and civil construction areas, gases like CO_2, earth dust, air particulates, abnormal gases, dusty area, etc. All the produce health issues when respired. The contaminated particles and air should be cleaned to reduce the respiratory from inhalation of the air. The respiratory organ may be produced to progression of sicknesses like asthma attack, etc. Bigger earth particles square-up a measure for significant waste material among these and the air in the surrounding will need a purification process as to the standard levels of pure air. Despite the fact that these measure undergo multiple processes of air track arrangement that square measure out there in market anyway none of them square measure sufficiently spare to convey its working intensity

298

2. Context

The context chapter explains the current situation on the air purifier market in terms of the environment, design, functions and design challenges. A benchmarking exemplifies how current competitors tackles typical design challenges in the development of air purifiers and how they meet user needs.

2.1 AIR PURIFIER

2.2 HOW IT WORKS

Various Initiatives undertaken by Government for mitigation of Air Pollution

Posted On: 22 NOV 2019 2:39PM by PIB Delhi

Government is taking all efforts for the mitigation of air pollution in the country. Central Government has taken a number of regulatory measures for prevention, control and abatement of air pollution in the country.

Action Plans for Improvement of Air Quality

i. The Central Government has launched National Clean Air Programme (NCAP) under the Central Sector "Control of Pollution" Scheme as a long-term, time-bound, national level strategy to tackle the air pollution problem across the country in a comprehensive manner with targets to achieve 20 % to 30 % reduction in PM_{10} and $PM_{2.5}$ concentrations by 2024 keeping 2017 as the base year for the comparison of concentration. 102 non-attainment cities mostly in Indo-Gangetic Plains have been identified based on ambient air quality data for the period 2011 – 2015 and WHO report 2014/2018. The city specific Action Plans have been approved for all 102 non-attainment cities for implementation on ground.

ii. The Central Government has notified a Comprehensive Action Plan (CAP) in 2018 identifying timelines and implementing agencies for actions identified for prevention, control and mitigation of air pollution in Delhi and NCR.

iii. Graded Response Action Plan (GRAP) was notified on January 12, 2017, for prevention, control and abatement of air pollution in Delhi and NCR. It identifies graded measures and implementing agencies for response to four AQI categories, namely, Moderate to Poor, Very Poor, Severe and Severe + or Emergency.

(b) Several steps have been taken for creating awareness amongst the general population. These steps are as follows.

- SAMEER app has been launched wherein air quality information is available to public along with provision for registering complaints against air polluting activities.
- Air quality information collection and dissemination are done from a centralized location. It provides real time air quality status to all stakeholders.
- A dedicated media corner, Twitter and Facebook accounts have been created for access to air quality related information and to provide a platform for lodging complaints by general population.
- Crowd sourcing of innovative ideas/ suggestions/proposals from public is done through CPCB website to strengthen efforts for improving air quality in Delhi-NCR.
- The Ministry of Environment, Forest and Climate Change is implementing Environment Education, Awareness and Training Scheme with the objective to promote environmental awareness among all sections of the society and to mobilize people's participation for conservation of environment. Under the National Green Corps (NGC) programme of the Ministry, about one lakh schools have been identified as Eco-clubs, wherein, nearly thirty lakh students are actively participating in various environment protection and conservation activities, including the issues related to the air pollution.
- Ministry is promoting peoples participation and awareness building among citizens for environmental conservation that focus on promotion of cycling, saving water and electricity, growing trees, proper maintenance of vehicles, following of lane discipline and reducing congestion on roads by car pooling etc.

2.0 AIR POLLUTION PROBLEM IN INDIA

Air pollution in India is mainly caused from three sources namely vehicles, industrial and domestic sources. The air pollution is mainly concentrated in following three areas

(i) **Major Cities**: The problem of air pollution is in major cities where the prominent source of air pollution is vehicles and small/medium scale industries. These cities include Delhi, Kolkata, Mumbai, Chennai, Ahmedabad, Bangalore, Hyderabad, Pune, Kanpur etc. A study carried out in Delhi shows the contribution of industrial (including thermal power plants), vehicular and domestic sources of pollution to the ambient air in Delhi as follows (Table 2.1, Source: MoEF, 1997).

Table 2.1 Contribution of air pollution from various sources in Delhi (Source MoEF, 1997)

Source	1970-71	1980-81	1990-91	2000-01 (Projected)
Industrial	56%	40%	29%	20%
Vehicular	23%	42%	64%	72%
Domestic	21%	18%	7%	8%

(ii) Critically Polluted Areas: 24 critically polluted areas have been identified in India where the problem of pollution exists. These areas are as follows:

Table 2.2 : Problem Areas in India

S.No.	Problem Area	Type of Industry
1	Singrauli	Power Plants, Mining, Aluminium Industry.
2	Korba	Power Plants, Aluminium Industry, Mining.
3	Vapi	Chemical Industries.
4	Ankaleshwar	Chemical Industries.
5	Greater Cochin	Oil Refineries, Chemical, Metallurgical Industries
6	Visakhapatnam	Oil Refinery, Chemical, Steel Plants.
7	Howrah	Foundry, Rerolling Mills
8	Durgapur	Chemical Industries, Power Plants, Steel Plants .
9	Manali	Oil Refineries, Chemical Industry, Fertilizer Industry
10	Chembur	Refineries, Power Plant, Fertilizer Industry.
11	Mandi Gobindgarh	Secondary Steel Industry
12	Dhanbad	Mining, Coke Oven
13	Pali	Cotton Textile, Dyeing

4

Government Regulations

THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981

No. 14 of 1981

[29th March, 1981]

An Act to provide for the prevention, control and abatement of air pollution, for the establishment, with a view to carrying out the aforesaid purposes, of Boards, for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

WHEREAS decisions were taken at the United Nations Conference on the Hum an Environment held in Stockholm in June, 1972, in which India participated, to take appropriate steps for the preservation of the natural resources of the earth which, among other things, include the preservation of the quality of air and control of air pollution;

AND WHEREAS it is considered necessary to implement the decisions aforesaid in so far as they relate to the preservation of the quality of air and control of air pollution;

BE it enacted by Parliament in the Thirty-second Year of the Republic of India as follows :-

CHAPTER I
PRELIMINARY

1. Short title, extent and commencement.

(1) This Act may be called the Air (Prevention and Control of Pollution) Act, 1981.

(2) It extends to the whole of India.

(3) It shall come into force on such date[1] as the Central Government may, by notification in the Official Gazette, appoint.

2. Definitions.

In this Act, unless the context otherwise requires,-

(a) "air pollutant" means any solid, liquid or gaseous substance [2][(including noise)] present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment;

(b) "air pollution" means the presence in the atmosphere of any air

(c) "approved appliances" means any equipment or gadget used for the bringing of any combustible material or for generating or consuming any fume, gas of particulate matter and approved by the State Board for the purpose of this Act;

(d) "approved fuel" means any fuel approved by the State Board for the purposes of this Act;

(e) "automobile" means any vehicle powered either by internal combustion engine or by any method of generating power to drive such vehicle by burning fuel;

(f) "Board" means the Central Board or State Board;

(g) "Central Board- means the [3][Central Board for the Prevention and Control of Water Pollution] constituted under section 3 of the Water (Prevention and Control of Pollution) Act, 1974;

1.2 National Ambient Air Quality Standards (NAAQS)

The ambient air quality objectives/standards are pre-requisite for developing programme for effective management of ambient air quality and to reduce the damaging effects of air pollution. The objectives of air quality standards are: -

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property.
- To assist in establishing priorities for abatement and control of pollutant level;
- To provide uniform yardstick for assessing air quality at national level; and
- To indicate the need and extent of monitoring programme.

2

The Central Pollution Control Board had adopted first ambient air quality standards on November 11, 1982 as per section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act, 1981. The air quality standards have been revised by the Central Pollution Control Board on April 11, 1994 and were notified in Gazette of India, Extra-ordinary Part-II Section 3, sub section (ii), dated May 20, 1994. The revised National Ambient Air Quality Standards are depicted in Annexure-I (Table A1.1). These standards are based on the land use and other factors of the area. The guidelines for declaring sensitive areas as recommended by peer/core group of CPCB are as follows:

Sensitive areas – sensitive area may include the following:

1) 10 kms all around the periphery of health resorts so notified by State Pollution Control Boards in consultation with department of public health of the concerned state.

2) 10 kms all around the periphery of biosphere reserves, sanctities and national parks, so notified by Ministry of Environment and Forest or concerned states.

3) 5 kms all around the periphery of an archeological monument declared to be of national importance or otherwise so notified by Archeological Survey of India (A.S.I.) in consultation with State Pollution Control Boards.

4) Areas where some delicate or sensitive to air pollution crops/important to the agriculture/horticulture of that area are grown so notified by State Pollution Control Boards in consultation with department of agriculture/horticulture of concerned state.

5) 5 kms around the periphery of centers of tourism and/or pilgrim due to their religious, historical, scenic or other attractions, so notified by department of tourism of the concerned state with State Pollution Control Boards.

Stakeholders

Clitizen

Family
Children
Working professionals
Daily wage workers

Government agencies

Municipal Corporation
PWD

Government

Policy creation
Governance

Technologist

R&D thinkers
Institutions
NEERI

Regulatory agencies

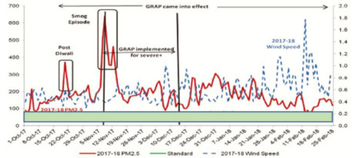
Central Pollution Control Board

Seasonal changes in AQI

a considerable seasonal variation in the concentration of all pollutants. Most of the pollutants peak in the post-monsoon season, followed by winters in which crop residue burning predominates in many parts of the Haryana. PM10 concentrations increased by 65-112% and PM2.5 concentrations increased by 131-147% in the post-monsoon season compared to monsoons.

Due to the Diwali fire crackers and stubble burning in November the AQI becomes peak.

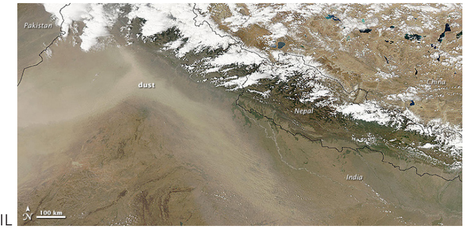
Even if we do some policy changes and reduce the air pollution of Diwali and stubble burning to zero still the average AQI for the whole year will be 150 which is very unhealthy.



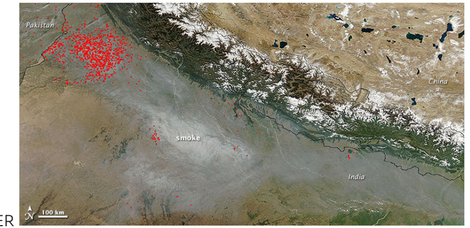
Seasonal peaks happens during Diwali and stubble burning with a average AQI of 150

MARCH

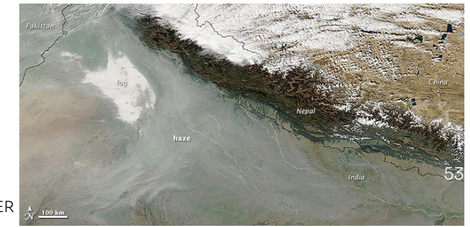
APRIL



NOVEMBER



DECEMBER



Interviews

It is mentioned how challenging it is to gauge the performance of the air purifiers outside.

The machines, according to some people, did not stop pollution at its source.

Organize a thorough public awareness campaign on the prevention, control, or reduction of air pollution using the social media.

The focus is on major policy changes to curb air pollution. In Delhi they have already closed down two power plants and implemented rules on stubble burning. The result is that there is already less average AQI this year.

Delhi is heavily investing on tried and tested technologies. Failure of the previous two projects has brought skepticism in the CPCB. They will not be investing in any project without a prior trial.

In New Delhi, at the ITO Junction, CPCB operates an automatic monitoring station. At this station, carbon monoxide (CO), ozone (O3), sulphur dioxide (SO2), nitrogen dioxide (NO2), and suspended particulate matter (SPM) are all regularly observed airborne pollu

To ascertain the current status and trends of air quality as well as to control and regulate pollution from factories and other sources to comply with air quality regulations, the National Air Monitoring Programme (NAMP) was developed.

Major legislative measures are being prioritised to reduce air pollution. Delhi has already stopped burning stubble and shut down two power units. As a result, this year's AQI is lower than typical as expected.

The government is having big budget on monitoring air quality. Using the information now available can assist in developing more methods to tackle the issue.

WAYU needed ongoing maintenance and monitoring. NERRI engineers initially performed the maintenance, which was thereafter turned over to the Delhi municipal government. The maintenance calls for the appropriate training.

The machines are specifically designed to function in areas with high pollution levels.

The machines have filters made of activated charcoal and non-woven fabric such as porous sheets of plastic film. This helps trap particulate matter 2.5 and 10.

Central Pollution Control Board
Ministry of Environment, Forest and Climate Change
Government of India

सत्यमेव जयते

CPCB

Informal discussions with people working in this field

Informal discussion with Amol Chaphekar:
Had bad experience working with IITs before. Will not share any information regarding the designs or technology.
He has successfully designed tamper proof designs.
Does not work with Indian govt. due to corruption. He essentially works with governments of other countries like uk, germany, etc
Gave other inputs.
It takes 45 days for production and another 45 days to transport and install the purifiers.
Cost of manufacturing varies from 1 lakh to 1.2 crores depending on models.
Manufacturing happens at his plant outside Pune.
He has 18 patents in this field in areas of technology, design and manufacturing.

Informal discussion with Prof. Manoranjan Sahu (environmental sciences dept.) :
Undertook the project of smoke tower located in CP, Delhi.
Its classified project with govt. of India, so will only tell generic information.
On average the tower uses alot of electricity.
It is still an ongoing project. Maintenance is required.
Since the start of this tower its continuously being reworked on.
He recently visited delhi to oversee the functioning of this tower.
Working on smaller projects.

Other such outdoor air purifiers in India

Hyderabad's Outdoor Air Purifiers

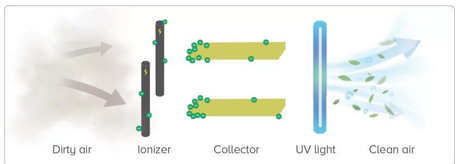
Hyderabad is one of the cities suffering from air pollution. In an effort to help Hyderabad breathe easier the Greater Hyderabad Municipal Corporation (GHMC) has decided to set up outdoor air purifying units across select locations in the city. The GHMC intends to set up these air purifying units at three locations in the city– Gachibowli, Jubilee Hills, and Panjagutta, where air pollution levels spike during peak traffic hours. The air purifiers would pull in polluted air, filter it and release fresh air. Each unit ranges from Rs 50,000 to Rs 12 lakh depending on its capacity. The managing director of Strata Enviro, Amol Chaphekar, said that the air purifying machines will help bring down air pollution spikes at the locations where they are installed. When asked if the technology works, Anmol responded by saying, "The first two years after forming the company in 2016 went in trying to prove that the technology works. Our air filtering system is patented and has been proven successful in Mumbai and Delhi. In Delhi the air purifiers have been mounted on the buses; when the bus stops due to traffic, the air purifier becomes operational and cleans the air. We even got a grant from the Department of Science after they were satisfied with our project." They are best located at traffic signals, railway stations and bus stands where maximum number of people are moving around, he added

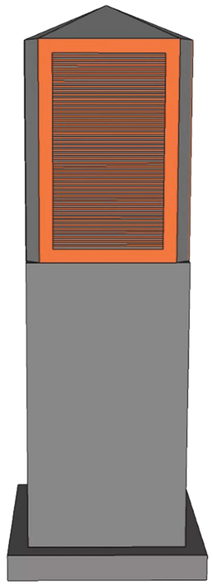
Innovative Plant-Based Air Purifier

An Indian startup has developed a smart plant-based air purifier called Ubreathe Life. Tested by the National Accreditation Board for Testing and Calibration Laboratories, it was found to significantly reduce the Air Quality Index (AQI) from 311 to 39 within just 15 minutes of usage.
Ubreathe Life incorporates a living plant as part of the air purification device. When installed in a room, the air comes into contact with the plant's leaves and passes through the soil-root zone where pollutants are purified. This plant-based purifier utilizes a technology called Urban Munnar Effect and benefits from the plants' breathing roots, which enhance the phytoremediation process.
The device effectively improves indoor air quality and removes particulate, gaseous, and biological contaminants, while also increasing oxygen levels. It consists of specific plants, UV disinfection, and a stack of pre-filter, charcoal filter, and high-efficiency particulate air filter, all housed in a wooden box that serves as the plant's base. A centrifugal fan creates a low-pressure area inside the device, generating suction and releasing purified air in all directions, particularly at the plant's roots.
Given the growing importance of air quality, especially in the context of the Covid-19 pandemic, plant-based air purifiers offer a valuable solution for promoting healthier living environments.

Prana Air

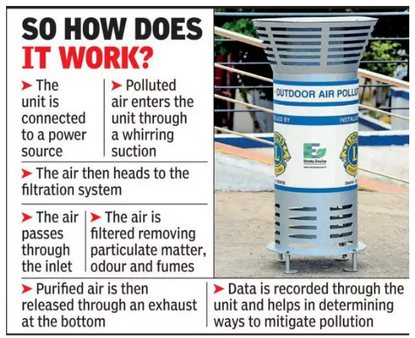
Prana Air, a product brand launched by Purelogic Labs India, was born out of a personal experience of struggling to breathe fresh air and the growing concerns about public safety. With pollution affecting every city in the country, Prana Air aims to address this issue on a mass scale. Specializing in air quality monitoring devices and clean air solutions for both indoor and outdoor environments, Prana Air offers affordable, smart, and highly accurate products for households and businesses. With a deep understanding of the ongoing fight against air pollution, their prototypes have undergone rigorous testing and received positive validation from customers.
Based in New Delhi, India, Prana Air focuses on air quality monitors, sensors, fresh air machines, room air purifiers, and motorized HEPA filter pollution masks to safeguard people's health. Their outdoor air purifier effectively captures over 80 percent of particulate matter, including bacteria and viruses, using advanced technology such as pre-filters and electrostatic filters. Additional features like U light and negative ion ionizers further enhance air quality by reducing bacteria and viruses in the area.
Recognizing the uneven distribution of fast-moving air contaminants, Prana Air emphasizes high spatial and temporal resolution in outdoor air quality filtration. Their solutions find wide applications in various outdoor settings, aiming to provide healthier air for all.



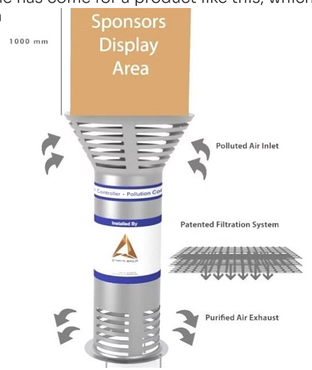


Strata Enviro

Strata Enviro, led by Amol Chaphekar in Pune, offers a potential solution to the air pollution challenges faced by Indian towns and cities. Their outdoor air purifier devices, called Outdoor Air Pollution Controllers, have undergone successful testing in schools, hospitals, and toll booths in Maharashtra and Delhi. With 300 units proven effective, they are now poised for a nationwide launch.
These pollution controllers, priced at Rs. 70,000 each, can potentially recover their cost through advertising when installed in public spaces, making them nearly free. Amol's ambitious mission is to supply 100,000 units across India, which would require substantial funding from the government or a strategic partnership with a manufacturing house.
Strata Enviro received support from esteemed organizations like Nasscom Foundation, the Indian Institute of Management in Ahmedabad, the Rotary Club of Pune Royal, and the Centre's Department of Science and Technology during the development of their innovative device.



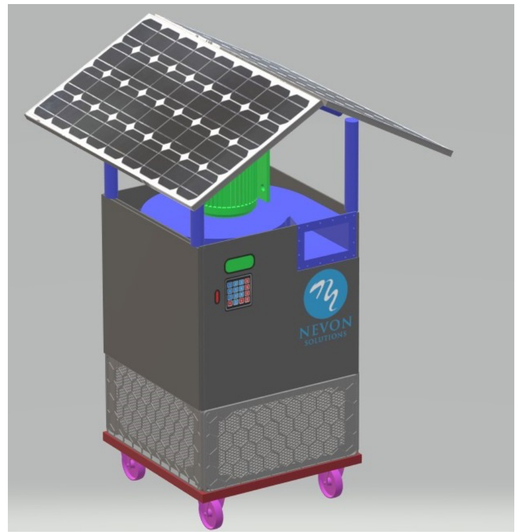
The outdoor air purifiers are IoT-ready, equipped to filter pollutants such as PM 2.5, PM 10, dust, and petroleum fumes from the air. They can be installed in high pollution zones, including traffic signals, congested areas, toll booths, railway stations, airports, and fuel stations. With a range of 60 feet, these units significantly improve air quality and can even be mounted on vehicles. The integration of IoT technology enables remote control and data logging, facilitating easy monitoring of air quality.
While dealing with government agencies for approval of installations at public locations poses a challenge, the urgency of the air pollution problem suggests that the time has come for a product like this, which has the potential to make a significant impact.



Nevon Projects, Solar Outdoor Air Purifier

Traditional indoor air purifiers lack the purifying capability required for outdoor spaces, and outdoor machines face power supply challenges. To overcome these limitations, we have designed a heavy-duty outdoor air purifier specifically tailored for outdoor purification. Powered by solar panels, this purifier operates independently, utilizing sustainable energy.
Our solar air purifier incorporates a robust suction fan that draws air from the bottom of the device, passing it through a dual-layer filtration system consisting of HEPA and Carbon filters. This effective filtration process eliminates PM 10, PM 2.5 pollutants, as well as gases.
The purification mechanism involves a two-layer filtration approach, with the first layer consisting of a HEPA filter and the second layer utilizing an active carbon filter. This combination enables dual filtration, employing centrifugal air force to efficiently draw in a large volume of air and purify it from dust particles.
The powerful suction fan creates high-power centrifugal force, extracting air from the bottom and expelling fresh purified air from the top. The system also includes an air quality sensor and display to provide real-time monitoring of air quality. Solar panels are utilized for power supply, charging a battery that in turn powers the motor driving the suction fan.
For enhanced convenience and mobility, the machine is equipped with four castor wheels and a handle, making it easily portable. This allows for swift deployment in school play areas, parks, residential areas, and other public spaces, enabling efficient and instant pollution control.

Approximate Size of the purifier: 500 x 500 x 1600mm (Length x Width x Height)



SECTION 1 B

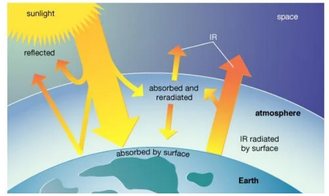
About Solar Panels

Solar Energy

Solar energy is a form of radiation from the Sun that has the ability to generate heat, trigger chemical reactions, and produce electricity. The amount of solar energy reaching Earth is significantly greater than the current and future energy needs of the world. If effectively harnessed, this widely available and renewable source has the potential to meet all our energy requirements.

Solar energy is gaining increasing popularity as a renewable energy source in the 21st century. It stands in stark contrast to finite fossil fuels like coal, petroleum, and natural gas, as it is both abundant and environmentally friendly. Although the Sun is an incredibly powerful energy source and sunlight is the largest energy source received by Earth, the intensity of sunlight at the Earth's surface is relatively low. This is primarily due to the vast spreading of radiation from the distant Sun. Additionally, the Earth's atmosphere and clouds absorb or scatter a significant portion, around 54 percent, of incoming sunlight.

The sunlight that manages to reach the ground is composed of approximately 50 percent visible light, 45 percent infrared radiation, and smaller amounts of ultraviolet and other forms of electromagnetic radiation. The potential of solar energy is immense, with Earth receiving about 200,000 times the world's total daily electric-generating capacity in the form of solar energy every day.



However, despite solar energy being freely available, its widespread utilization is limited by the high costs associated with its collection, conversion, and storage. Solar radiation can be converted into either thermal energy (heat) or electrical energy, with the former being relatively easier to accomplish.

In summary, solar energy is a highly abundant and renewable source of radiation from the Sun that holds tremendous potential to meet our energy needs. It is clean, nonpolluting, and stands in contrast to finite fossil fuels. While the cost of harnessing solar energy remains a challenge, ongoing advancements in technology are making it increasingly attractive as a viable energy solution.

Thermal energy

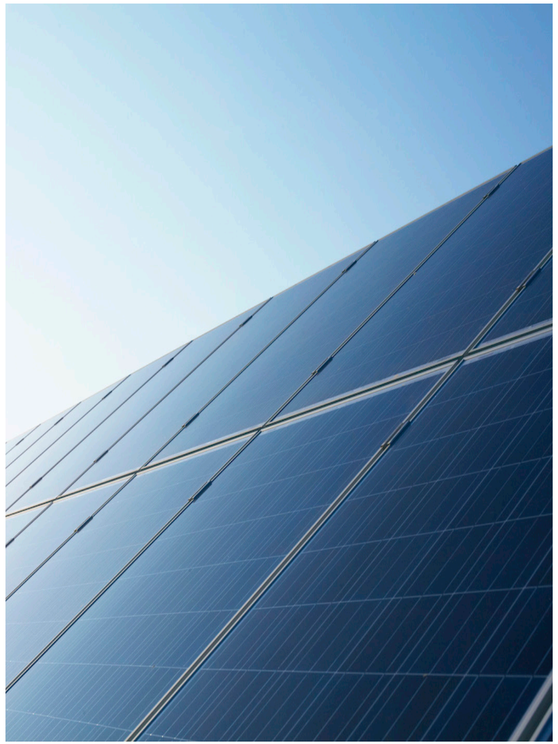
Flat-plate collectors are commonly used devices to capture solar energy and convert it into thermal energy for various applications, such as solar heating. Due to the low intensity of solar radiation at Earth's surface, these collectors need to be large in area. In sunny parts of temperate regions, for example, a collector typically requires a surface area of about 40 square meters (430 square feet) to gather enough energy for one person's needs.

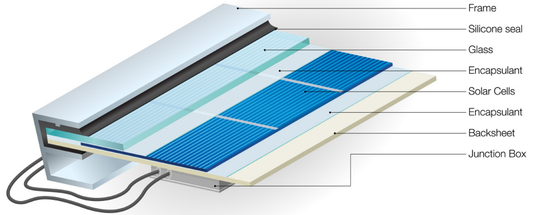
The most commonly used flat-plate collectors consist of a blackened metal plate covered with one or two sheets of glass. When sunlight falls on the plate, it heats up, and this heat is transferred to air or water, known as carrier fluids, flowing past the back of the plate. The heat can be used directly or transferred to another medium for storage. These collectors are frequently used in solar water heaters and house heating systems.

To store heat for use during nighttime or cloudy days, insulated tanks are commonly employed to store the water that has been heated during sunny periods. This stored hot water can be used for various purposes, such as providing hot water for household needs or circulating through tubes in floors and ceilings to provide space heating.

Flat-plate collectors typically heat carrier fluids to temperatures ranging from 66 to 93 °C (150 to 200 °F). The efficiency of these collectors, which measures the proportion of received energy converted into usable energy, can vary from 20 to 80 percent depending on the collector's design.

In summary, flat-plate collectors are utilized to capture solar energy for thermal applications. They rely on large surface areas to gather enough energy, and they use a blackened metal plate covered with glass to absorb sunlight and transfer the resulting heat to carrier fluids. These collectors are commonly used for solar water heaters and house heating, and the heat can be stored for later use. The efficiency of flat-plate collectors ranges from 20 to 80 percent, depending on their design.





Solar radiation can be converted directly into electricity using solar cells, also known as photovoltaic cells. When light strikes the junction between a metal and a semiconductor or between two different semiconductors, a small electric voltage is generated. Individual photovoltaic cells typically generate about two watts of power. However, by connecting numerous cells together in solar-panel arrays, it is possible to generate hundreds or even thousands of kilowatts of electric power in solar electric plants or large household arrays.

The energy efficiency of most current photovoltaic cells is around 15 to 20 percent. Due to the low intensity of solar radiation, large and expensive assemblies of these cells are required to produce even moderate amounts of power. However, small photovoltaic cells that operate on sunlight or artificial light have found widespread use in low-power applications like calculators and watches.

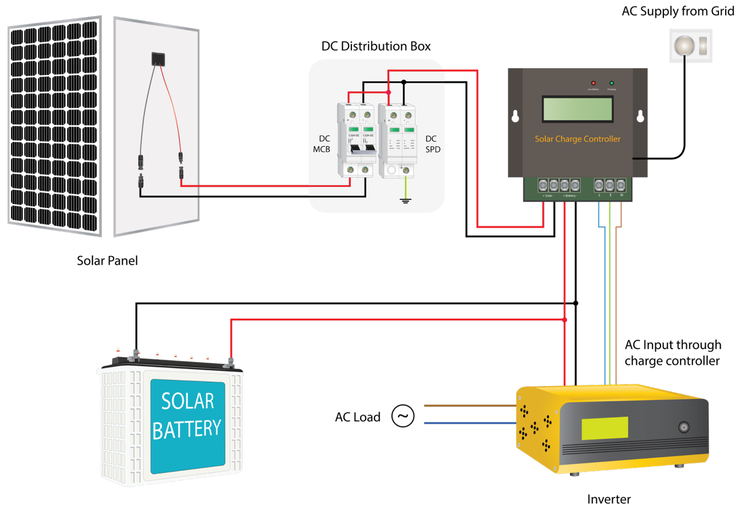
Larger units have been utilized for powering water pumps, communications systems in remote areas, and satellites for weather and communications purposes.

Solar power systems using classic crystalline silicon panels or emerging thin-film solar cell technologies, including building-integrated photovoltaics, can be installed on rooftops of homes and businesses to supplement or replace conventional electric supply.

Concentrated solar power plants use concentrating or focusing collectors to concentrate sunlight onto a small receiver, significantly increasing its intensity to generate high temperatures. Mirrors or lenses are carefully aligned to focus sunlight, allowing the target to reach temperatures of 2,000 °C (3,600 °F) or higher. This heat can be used to operate a boiler, which generates steam for a steam turbine electric generator power plant. Alternatively, movable mirrors can concentrate solar radiation onto blackened pipes through which water circulates, directly producing steam.

In summary, solar radiation can be converted into electricity through photovoltaic cells, either in small-scale applications or large-scale solar electric plants. The efficiency of photovoltaic cells is currently around 15 to 20 percent, requiring extensive arrays for significant power generation. Concentrated solar power plants utilize focusing collectors to increase sunlight intensity and generate high temperatures, which can be used for steam generation or to operate a steam turbine electric generator.

Process to convert into electricity



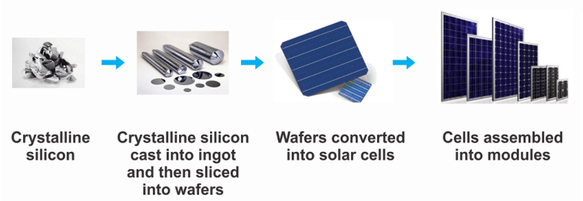
Hybrid Solar System

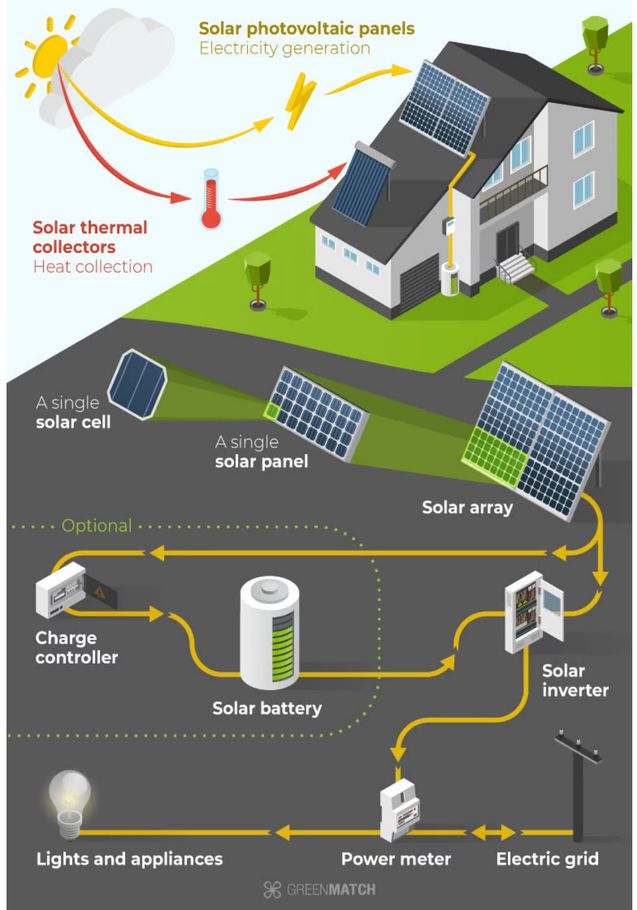
Manufacturing of photo-voltaic cells

Photo-voltaic cells, also known as solar cells, are manufactured through several key steps. The exact manufacturing process can vary depending on the type of solar cell technology used, but here is a general overview of the typical steps involved:

- Silicon Ingot Production: The process begins with the production of silicon ingots. High-purity silicon is melted and then solidified into large blocks or cylindrical ingots. These ingots serve as the base material for solar cells.
- Wafer Production: The silicon ingots are sliced into thin wafers using wire saws or other cutting methods. The wafers are usually around 180-200 micrometers thick and have a circular shape. They undergo surface treatment to remove any impurities and to create a uniform surface.
- Solar Cell Fabrication: The wafers are then processed to create the solar cell structure. This involves several steps:
  a. Surface Texturing: The front surface of the wafer is textured to increase light absorption by creating a rough surface that reduces reflection.
  b. Dopant Diffusion: A thin layer of dopant material, such as phosphorus or boron, is applied to create a junction that facilitates the separation of electrons and holes when sunlight is absorbed.
  c. Anti-Reflective Coating: A thin anti-reflective coating is applied to the front surface to further reduce reflection and enhance light absorption.
  d. Metal Electrode Formation: Metal contacts, typically made of silver or aluminum, are screen-printed on the front and back surfaces of the cell to collect the current generated by the absorbed light.
- Cell Testing: The fabricated solar cells undergo rigorous testing to ensure their performance and quality. Testing may include measuring parameters like efficiency, current-voltage characteristics, and durability.
- Module Assembly: Individual solar cells are connected in series or parallel configurations and encapsulated to form a solar module or panel. The cells are typically laminated between a protective front cover (often tempered glass) and a backsheet. Electrical junction boxes and connectors are added to facilitate module 1interconnections.
- Module Testing: The assembled solar modules undergo additional testing to evaluate their electrical output, mechanical strength, and durability. Testing may include performance under varying light conditions, temperature cycling, and other environmental stress tests.
- Final Packaging: The tested and approved solar modules are packaged and prepared for shipment. This may involve stacking and palletizing the modules for transport to customers or installation sites.

It's important to note that this is a simplified overview of the manufacturing process, and different solar cell technologies, such as thin-film or multi-junction cells, may involve additional or alternative steps. The production of photovoltaic cells requires specialized equipment, clean room facilities, and expertise in semiconductor fabrication techniques.





Types of Silicon solar cells

There are several types of solar cells, each utilizing different materials and technologies. Here are three common types:

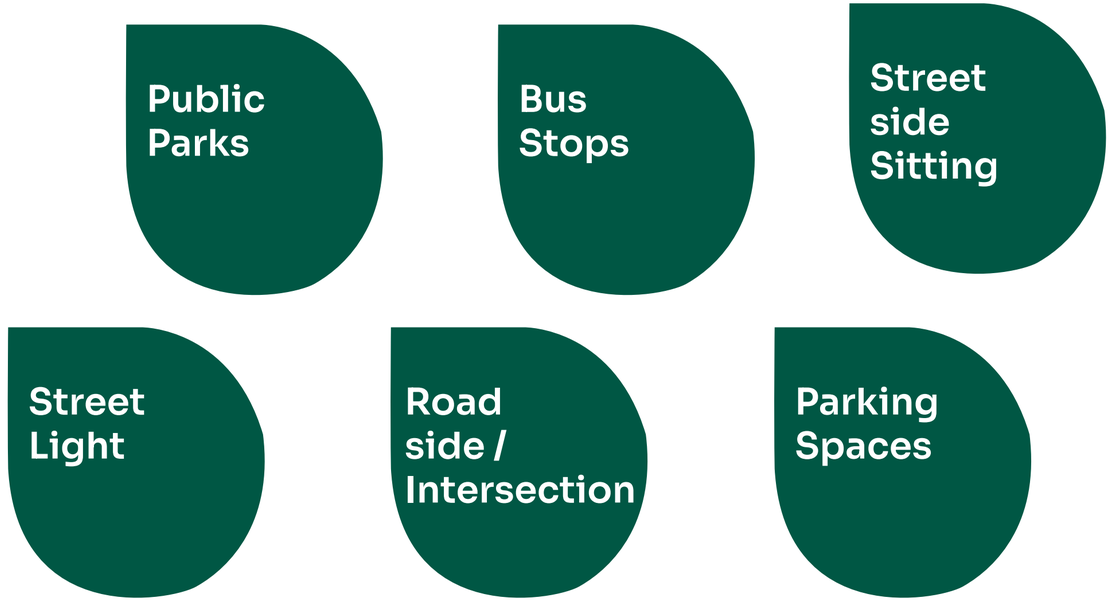
1. Crystalline Silicon Solar Cells: Crystalline silicon solar cells are the most widely used and commercially dominant solar cell technology. They are made from silicon wafers and can be further categorized into two types: monocrystalline and polycrystalline.
   a. Monocrystalline Silicon Solar Cells: Monocrystalline cells are made from single-crystal silicon, giving them a uniform and ordered structure. They have a high efficiency potential and are easily recognizable by their rounded edges and black appearance.
   b. Polycrystalline Silicon Solar Cells: Polycrystalline cells are made from multiple silicon crysb. tals, resulting in a more irregular and grainy appearance. They are slightly less efficient compared to monocrystalline cells but offer a more cost-effective option.
2. Thin-Film Solar Cells: Thin-film solar cells are made by depositing thin layers of semiconducting materials onto a substrate. These cells can be fabricated using different materials, including amorphous silicon (a-Si), cadmium telluride (CdTe), and copper indium gallium selenide (CIGS).
   - Amorphous Silicon (a-Si) Solar Cells: Amorphous silicon solar cells are made by depositing a non-crystalline form of silicon onto a substrate. They are flexible and lightweight, allowing for various applications, but typically have lower efficiency compared to crystalline silicon cells.
   - Cadmium Telluride (CdTe) Solar Cells: CdTe solar cells utilize a thin layer of cadmium telluride as the light-absorbing material. They are known for their high efficiency potential, low manufacturing costs, and suitability for large-scale installations.
   - Copper Indium Gallium Selenide (CIGS) Solar Cells: CIGS solar cells consist of a thin layer of copper, indium, gallium, and selenium compounds. They offer high efficiency potential, good low-light performance, and the ability to be manufactured on flexible substrates.
3. Organic Solar Cells: Organic solar cells, also known as organic photovoltaics (OPV), are made from organic compounds that can conduct electricity. They are typically lightweight, flexible, and have the potential for low-cost production. However, their efficiency is generally lower compared to other types of solar cells.
   - Organic Photovoltaic (OPV) Solar Cells: OPV cells use organic materials, such as polymers or small molecules, to create the active layer that absorbs sunlight and generates electricity. They are known for their potential to be produced using low-cost printing techniques and for their versatility in design and application possibilities.

These are just three examples of solar cell technologies, and ongoing research and development continue to explore new materials and technologies to improve efficiency, cost-effectiveness, and versatility in solar energy conversion.

SECTION 2

ENVIRONMENT STUDY

Common areas to tackle this problem

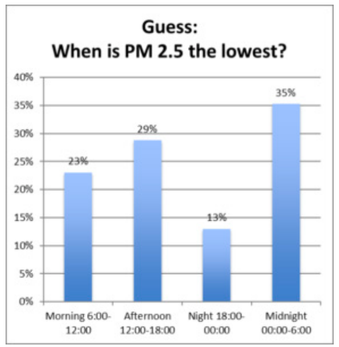


01

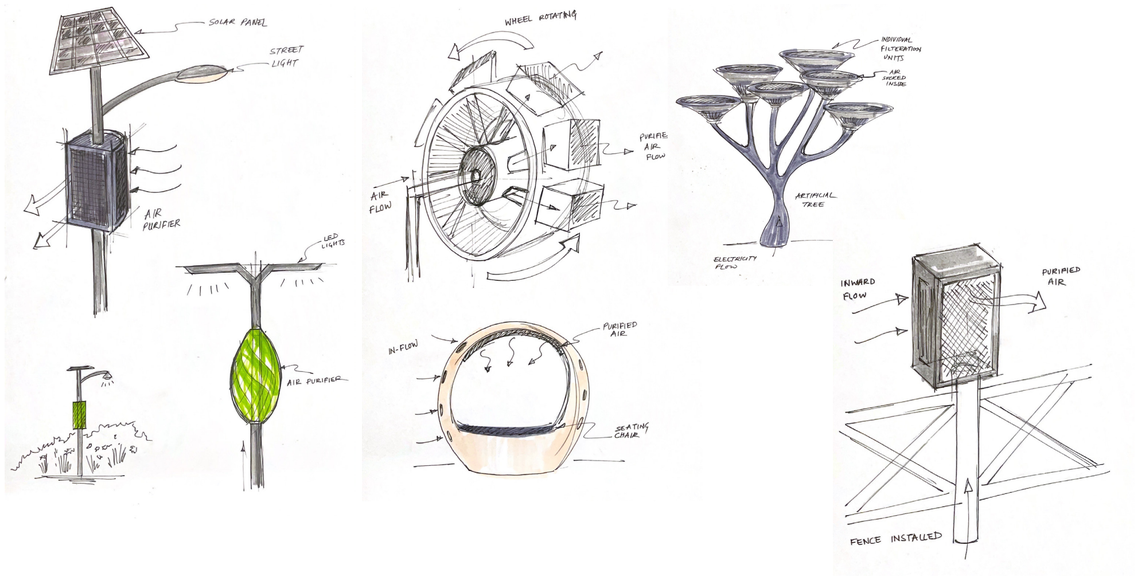
Public Parks

During my visit to the public parks in the Powai area, I made several intriguing observations regarding the air quality index (AQI) levels. It was astonishing to find that the AQI in the parks was consistently at least 10% lower than in the surrounding areas. As soon as I entered the park premises, I immediately sensed a refreshing change in the air quality. The atmosphere felt noticeably fresher, with a significant reduction in visible dust particles suspended in the air. In fact, the settled dust on the leaves of the trees further emphasized the disparity between the park's environment and the surrounding polluted areas.

Overall, the impact of air pollution seemed remarkably subdued within the park premises. The contrast in air quality was evident, and one could enjoy the experience of being surrounded by cleaner and healthier air while exploring the park. This observation highlights the significance of public parks as valuable green spaces that contribute to mitigating air pollution and providing an oasis of fresh air for visitors to enjoy.



Ideation based on parks as environment



Shortcomings

- Lack of concentrated pollution source
- Variable air quality
- Limited control over park activities
- High maintenance requirements
- Vandalism and theft risks
- Space constraints
- Potential interference with natural environment
- High initial and operational costs
- Public perception and acceptance
- Regulatory challenges
- Missed opportunity to preserve greenery
- Failure to leverage natural filtration
- Inconsistent with the park's tranquil atmosphere
- Potential negative impact on natural ecosystems
- Disruption of park aesthetics
- Limited scope for technology integration
- Potential conflict with park activities
- Uncertain effectiveness in an open environment

This comprehensive list highlights the drawbacks of not selecting a public park as an environment to design an outdoor air purifier. It includes factors such as the dispersion of pollution sources, variability in air quality, challenges in controlling park activities, high maintenance requirements, risks of vandalism and theft, space constraints, potential interference with the natural environment, cost considerations, public perception and acceptance, and regulatory complexities. Additionally, the list emphasizes the missed opportunities to preserve greenery and leverage natural filtration, as well as the disruption to the park's aesthetics and tranquil atmosphere.

02

Street side / intersections

Potentials

Designated clean air place to relax!

Air quality is very poor, so this product will make a difference

Improved air quality: The presence of air purifiers in public seating spaces helps to purify and filter the surrounding air, providing a designated area with cleaner and healthier air for people to relax and breathe in.

Enhanced comfort for the elderly: Well-maintained seating in these areas ensures a comfortable resting place for the elderly population, who may require a clean and peaceful environment.

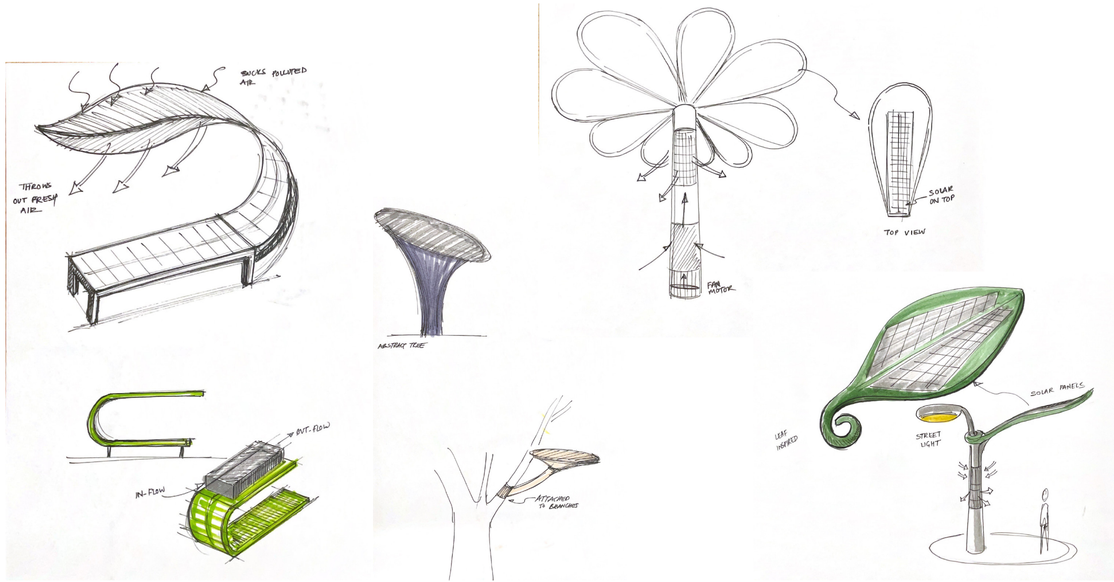
Creating a pleasant ambiance: The addition of outdoor air purifiers can contribute to creating a pleasant atmosphere, free from pollutants, and promote a sense of well-being for individuals using the seating spaces.

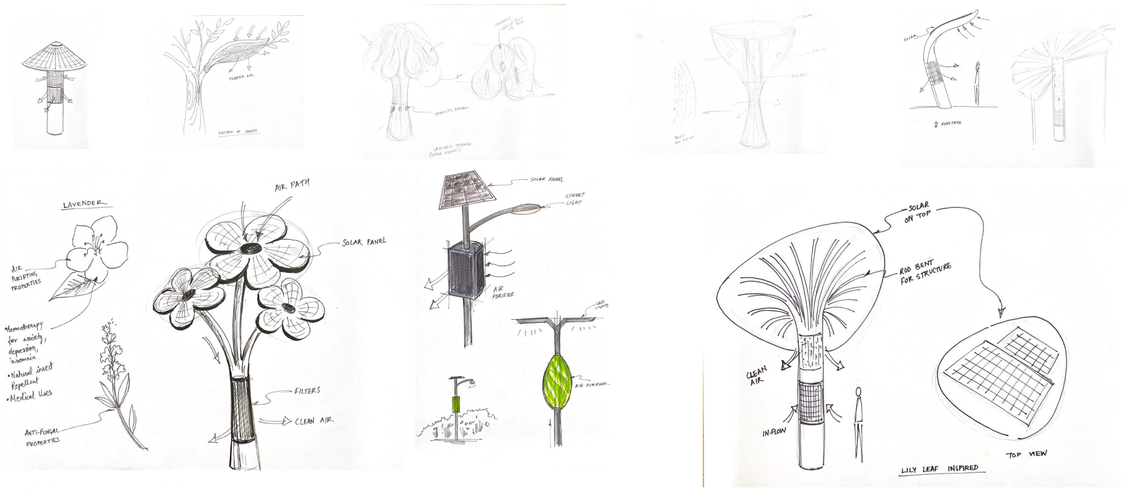
Addressing poor air quality: Public seating areas located in areas with poor air quality can greatly benefit from the presence of air purifiers, as they can effectively remove pollutants and make a noticeable difference in the surrounding air quality.

Initial design brief

To design an outdoor air purifier that will be powered by solar energy and willbe integrated with public seating spaces with primary focus on providing clean and safe environment for people.

Ideation based on street side spaces as environment





Shortcomings

Noise and visual impact: Air purifiers, particularly larger models, can generate noise during operation, which can disturb the desired peace and tranquility of outdoor seating areas. The presence of the equipment may also visually detract from the aesthetics of the space.

Space limitations: Integrating air purifiers into outdoor seating areas requires additional space for the equipment, filters, and ventilation systems. Street-side locations often have limited space available, making it challenging to find suitable areas for installation without compromising on the seating capacity or comfort.

Public acceptance and perception: Some members of the public may view the presence of air purifiers in outdoor seating areas as intrusive or unnecessary, potentially affecting the overall acceptance and popularity of the seating space. Concerns about the visual impact, noise pollution, and potential disruption to the outdoor experience could arise.

Power supply requirements: Outdoor seating areas may lack convenient access to a power source, making it difficult to operate and maintain air purifiers. The need for electricity or alternative power solutions can add complexity and additional costs to the installation.

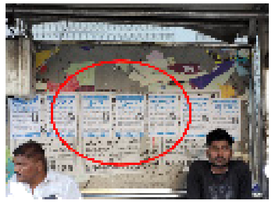
Cost: Integrating air purifiers into outdoor seating spaces can significantly increase the overall cost of the project. Expenses associated with purchasing, installing, and maintaining the equipment, as well as replacing filters, can be substantial.

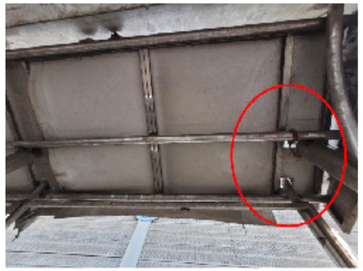
03

Bus Stops

Bus stops in Mumbai

Problem Areas





Air Quality Levels at Bus stop

- Air pollution and dust levels are highest.
- People of all ages have interactions with bus stop.
- Average number of people traveling in bus are 25 million commuters daily.
- Scope to improve in terms of overall usability and health.

The air quality at bus stops often presents higher levels of air pollution and dust compared to surrounding public spaces. This makes bus stops a critical area where the design and implementation of innovative solutions can have a significant impact.

Bus stops are frequented by people of all ages, making it a hub of activity and interaction. Considering the substantial number of commuters relying on buses, with an average of 25 million people traveling daily, there is a clear need to prioritize the improvement of bus stops in terms of usability and health.

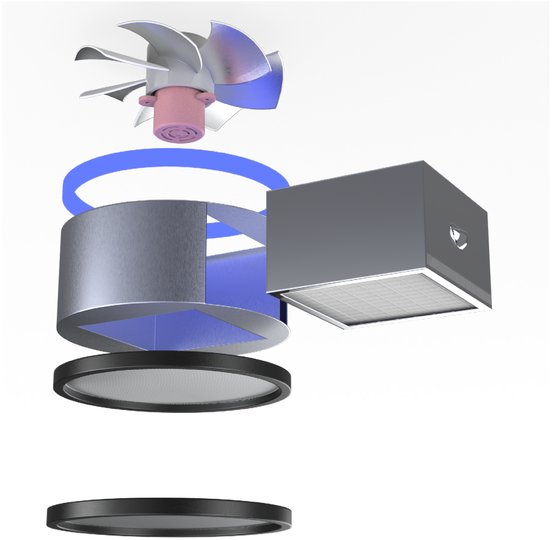
By designing new bus stops with a focus on air quality improvement, we can address the specific challenges related to air pollution and create healthier environments for commuters. This can involve incorporating features such as integrated air purifiers, dust filtration systems, and efficient ventilation mechanisms.

Improving the overall usability of bus stops goes beyond air quality considerations. It encompasses factors such as shelter from weather elements, comfortable seating arrangements, clear signage, adequate lighting, and amenities like accessible restrooms and vending machines. These enhancements can contribute to a more positive and convenient commuting experience for the millions of daily bus passengers.

Additionally, prioritizing the health aspect in bus stop design can have long-term benefits for commuters and the surrounding community. By implementing features like greenery, noise reduction measures, and sustainable materials, we can create a more pleasant and healthy environment. This can positively impact the physical and mental well-being of commuters, reducing stress and enhancing the overall quality of life.

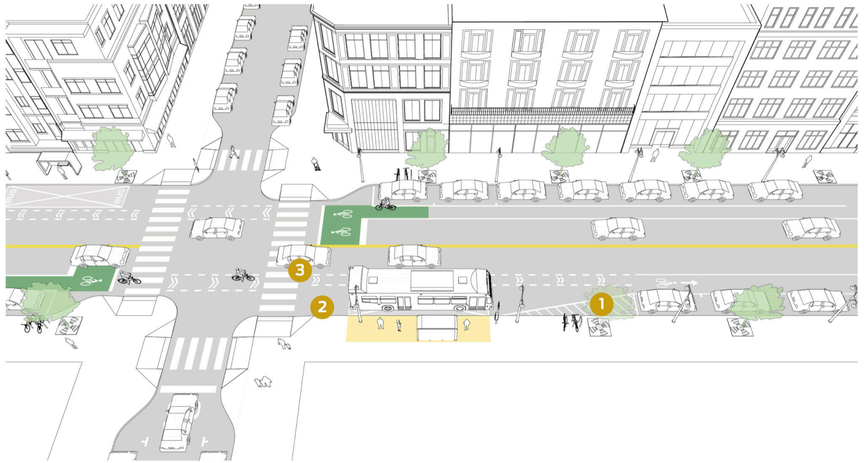
In conclusion, bus stops present a significant scope for improvement in terms of air quality, usability, and health. With high levels of air pollution and dust, coupled with the large number of daily commuters, designing new bus stops with innovative solutions can help create healthier and more user-friendly environments. By addressing air pollution, improving overall usability, and prioritizing health considerations, we can enhance the commuting experience for millions of people and contribute to a more sustainable and livable urban landscape.

The AQI (Air Quality Index) level at bus stops is typically higher compared to parks and other public spaces. This is mainly due to the presence of vehicular emissions, road dust, and the concentration of people waiting for buses in a confined area. The high levels of air pollution at bus stops can negatively impact the air quality and overall health of commuters and nearby residents.



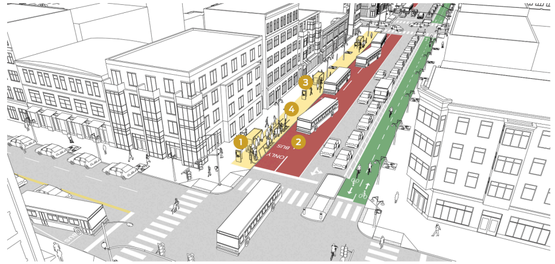
Standardization of bus stops

FAR-SIDE PULL-OUT WITH BIKE LANE



NACTO

DESIGN GUIDANCE



CRITICAL

1 Transit stop signs must clearly communicate which routes are served at which locations.

2 The on-street terminal must always operate in the curbside lane; to ensure stops remain unobstructed, all other curbside activities must be prohibited on the terminal side of the street.

Stop length must meet the criteria of a pull-out stop, though transition lengths may be shared between stops—one

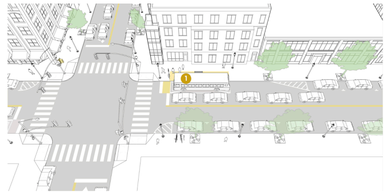
RECOMMENDED

Stopping patterns should be consistent to aid rider recognition. Signage and maps use letter or color motifs to communicate and reinforce stopping patterns, with each route consistently making stops in the same block location.

3 Strip maps, system maps, and wayfinding infrastructure should be consistently and prominently displayed to assist riders in finding correct stop locations.

OPTIONAL

4 For high-boarding stops with either all-door boarding or multiple lines, managed passenger queues may be implemented at the stop to speed boarding, sort passengers into distinct queues, and maintain a clear pedestrian zone on the sidewalk



This configuration is applicable where a neighborhood street crosses a larger street that may or may not be stop-controlled. If two similarly sized streets intersect with moderate to high traffic volumes, traffic signals with low-speed progressions may confer greater benefit to users.

1 At signal-controlled locations, the near-side pull-out stop may be implemented as a queue jump—the bus pulls into the stop, completes boardings, and then receives an advance or extended green phase through the intersection, while general traffic is held.

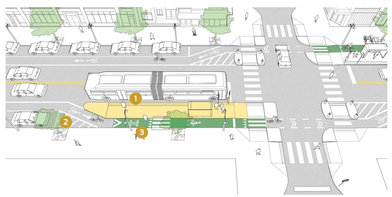
In stop-controlled configurations, the bus may pull into a near-side stop, allowing traffic behind to pull forward to the stop line and proceed while the bus is dwelling. When the bus completes boarding, it pulls forward and proceeds.

Where a small neighborhood street intersects a larger corridor or destination street and high transfer volume between intersecting routes is expected, the near-side stop can be paired with an adjacent far-side stop on the cross street, facilitating easy and safe transfer.

Locate the bus stop at least 10 feet from the crosswalk to ensure pedestrians and drivers have adequate sightlines.

Bus stop zone must be wide enough to ensure buses do not extend into adjacent lanes.

NEAR-SIDE STOP WITH BIKE CHANNEL AT SIDEWALK LEVEL



1 The boarding platform must at minimum span from the front door to the rear door, and may be extended to meet capacity demands.

2 The bicycle lane behind the floating boarding island can be at street grade or may be raised. Where the bike lane changes grade, bicycle ramps should not exceed a 1:8 slope. If raised, delineate bike and pedestrian realms using colored paint or paving materials.

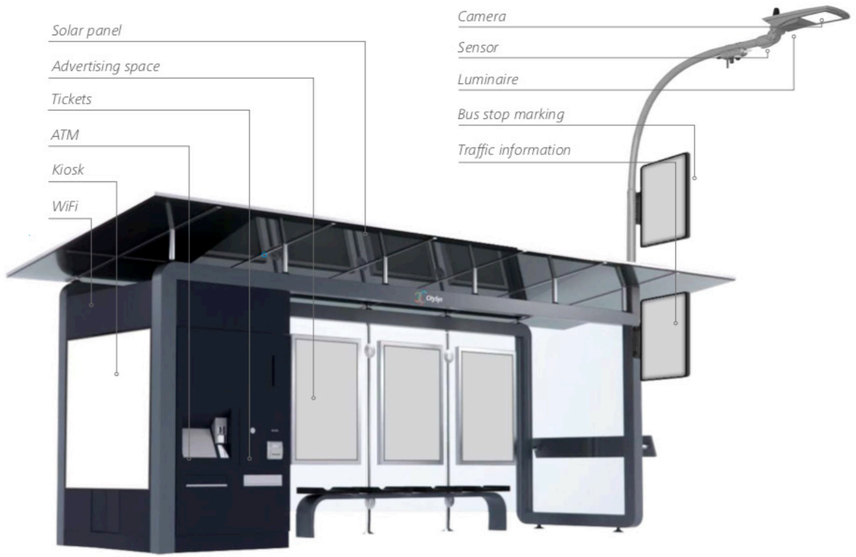
Bike lanes may be narrowed to slow bicycle traffic and reduce conflicts, with a minimum 5-foot width.

3 Mark pedestrian crossings through bike lane. Yield teeth and other markings and signs such as YIELD stencils and BIKES YIELD TO PEDESTRIANS (MUTCD R9-6) signs inform bicyclists of the requirement to yield to pedestrians.

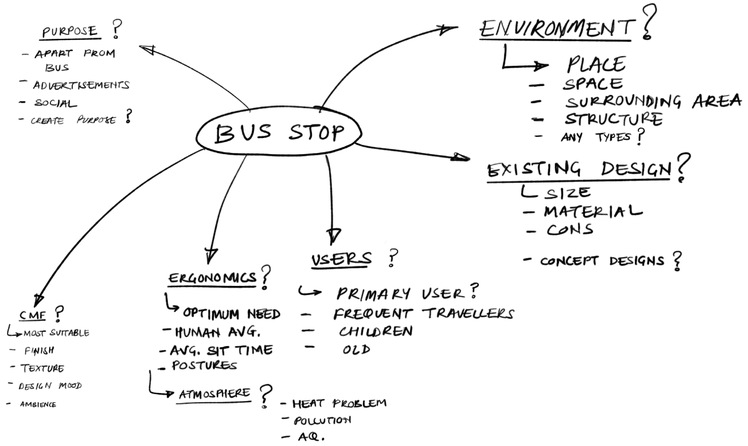
Where a near-side island is combined with a right-turn restriction, extend t refuge island into the intersection ar reduce the curb radius to self-enforc the turn restriction and provide additional pedestrian space.

Continuing the bike lane in a protect configuration through the intersectio simplifies interactions with pedestria and provides right-turning vehicles w a place to wait as they approach the

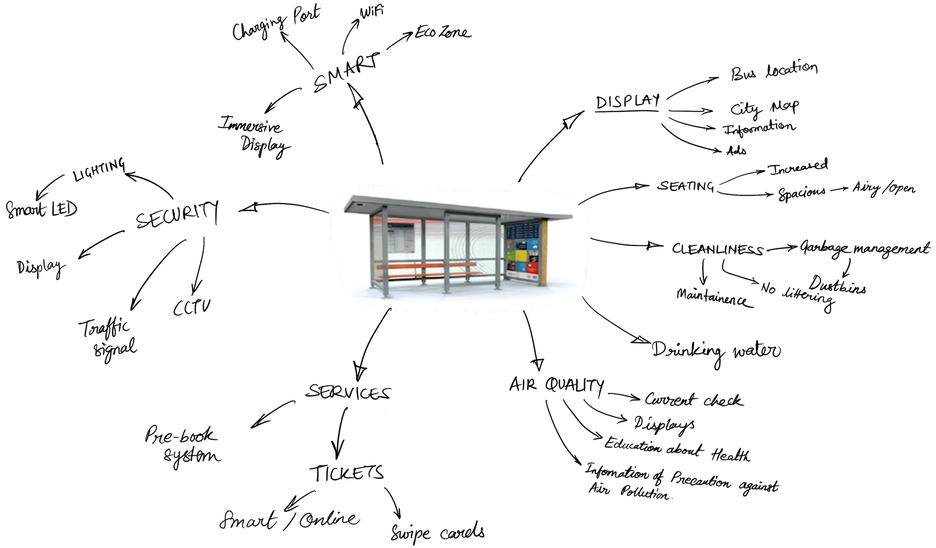
Parts of smart bus stop



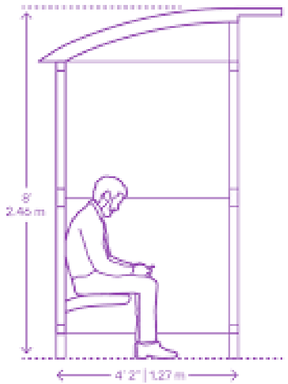
Mind map

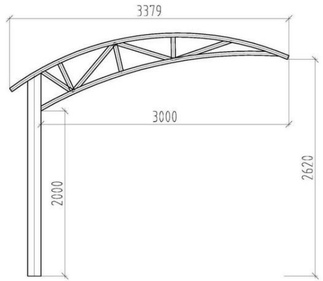


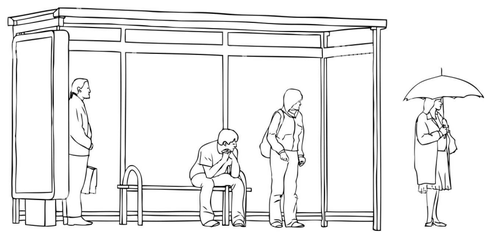
Mind mapping design possibilities

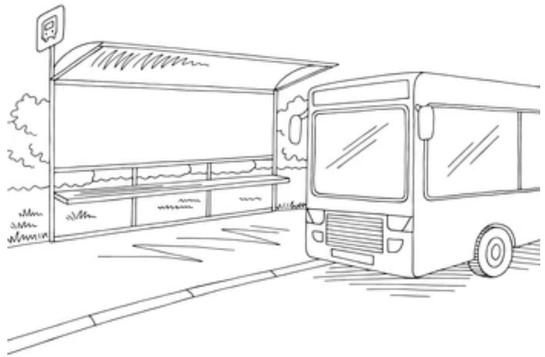


Ergonomic study









SECTION 3

DESIGN

Comfortable daily commute
Air purifier
Carbon Reducing energy solution

New Age Bus Stop experience

Design Brief

Project Title: Solar-Powered, Air-Purifying, Carbon Neutral Bus Stop with Smart System Features.

The goal of this project is to design a new age bus stop that is sustainable and promotes health. The bus stop should feature solar-powered technology, an air purifying system, smart displays, and other innovative features that make the bus stop a safe, comfortable, and convenient place to wait for the bus.

Project Objectives:
1. Sustainable and Carbon Neutral: carbon neutral, utilize solar power to generate electricity.
2. Air Purification: The bus stop should incorporate an air purifying system that improves the quality of air in the surrounding area, promote the health and well-being of commuters and contribute to a cleaner environment.
3. Smart System Features: The bus stop should include a variety of smart system features, including displays that show real-time information about bus routes, schedules, and arrival times. Other features could include a public Wi-Fi system, charging stations for mobile devices, and interactive maps of the surrounding area.
4. Health Benefits: The bus stop should be designed to promote health and wellness.
5. Safety and Security: The bus stop should be designed to be a safe and secure place for commuters. This could include features like lighting, security cameras, and emergency call buttons.

New age

Carbon reduction

Air purifier

Smart system

Health benefit

Safety & security

Design Objective

To design a new age bus stop integrated with air purifiers that will be powered by solar energy and having other smart features such as charging, lighting, displays, etc.

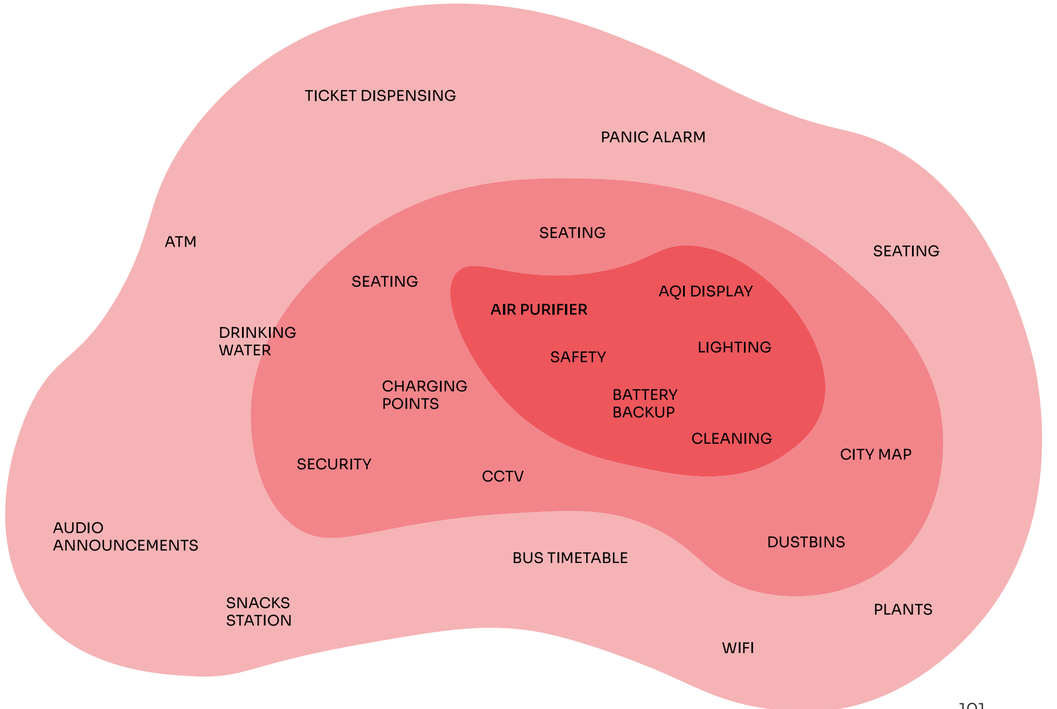
Design Keywords

- Grid- modular
- Subtle curves
- Futuristic look
- Open spaced- not cluttered
- Frame- minimum

Design specs list

- Air pollution, dust
- Display of information
- Seating
- Space utilization
- Lighting
- Safety, security
- Maintenance and cleaning of air purifier

Priority list for designing



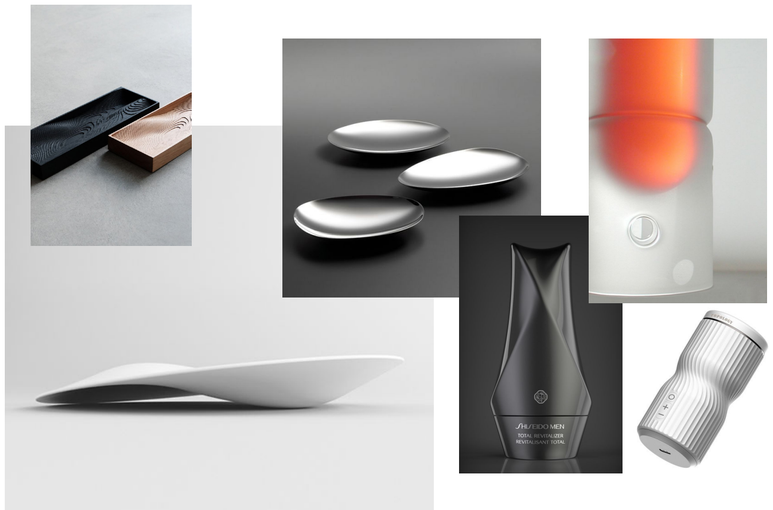
less is more .

Design Must - Haves based on priority list :

- Design specs list for bus stop
- Air purifier
- Maintenance and cleaning
- Lighting
- AQI information dis`play
- Battery pack
- Seating

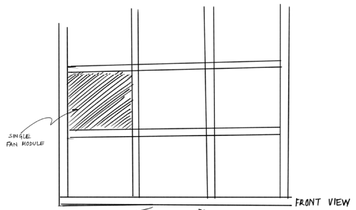
Moodboard

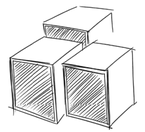
ORGANIC MORDERNISM

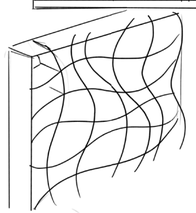


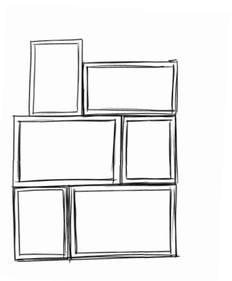
Clean lines
Smooth surfaces
Subtle curves
Minimal
Play of textures

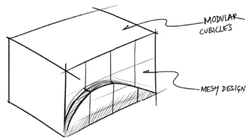
Ideation











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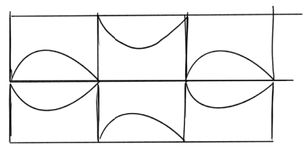

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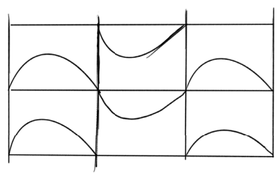
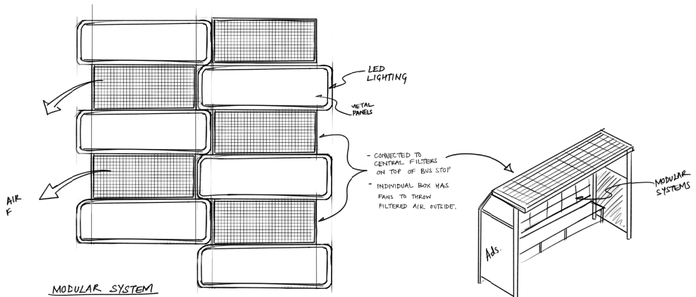
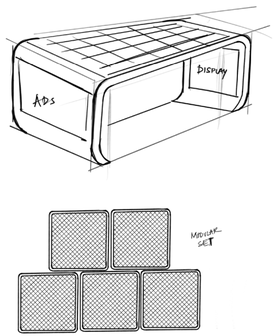
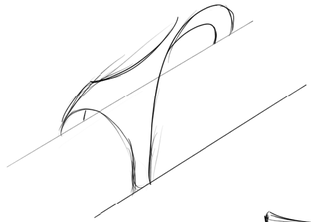
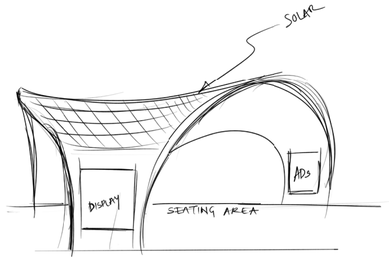
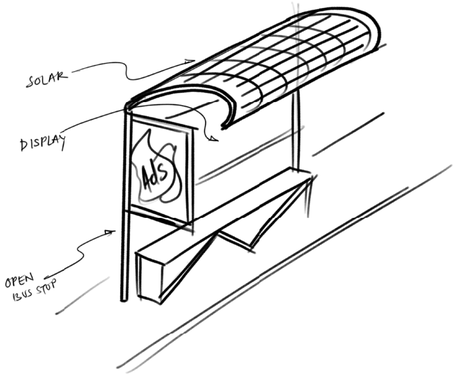


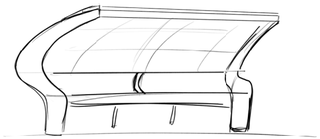

LED LIGHTING
METAL PANELS
AIR F
- CONNECTED TO CENTRAL FILTERS ON TOP OF BUS STOP
- INDIVIDUAL BOX HAS FANS TO THROW FILTERED AIR OUTSIDE.
MODULAR SYSTEMS
ADS
MODULAR SYSTEM
CENTRAL AIR PURIFIER

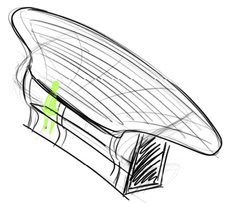

ADS
DISPLAY
MODULAR SET

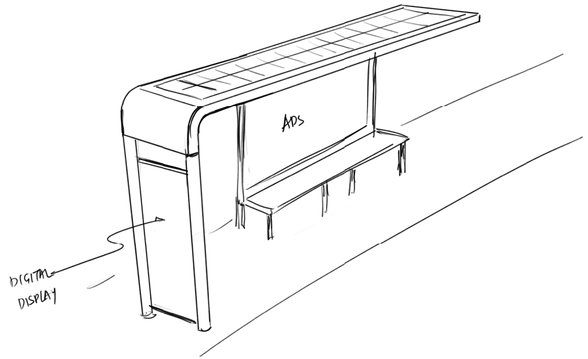


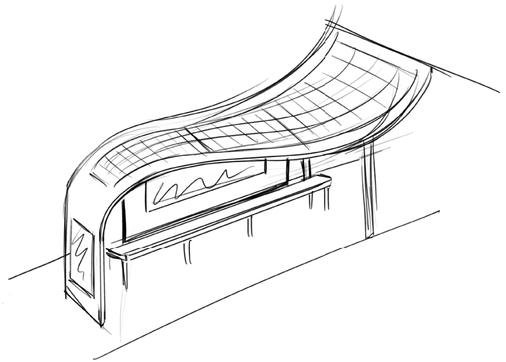

SOLAR
DISPLAY
ADS
SEATING AREA

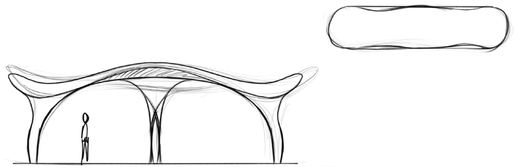

SOLAR
DISPLAY
ADS
OPEN BUS STOP

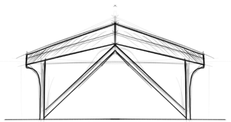


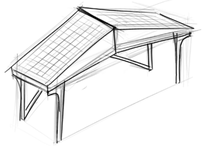


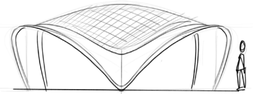

ADS
DIGITAL
DISPLAY

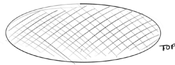


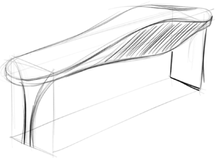


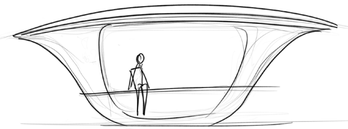


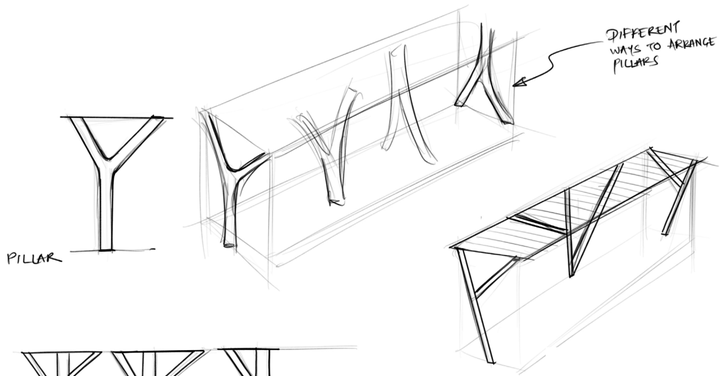


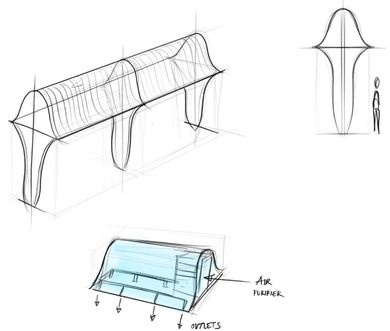


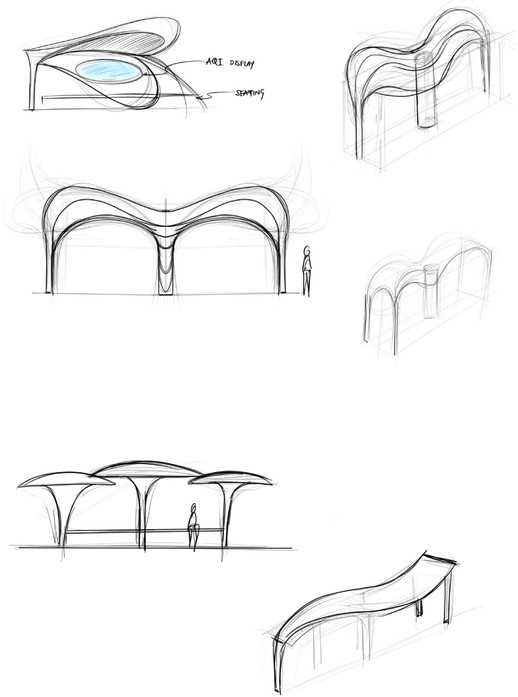

TOP VIEW

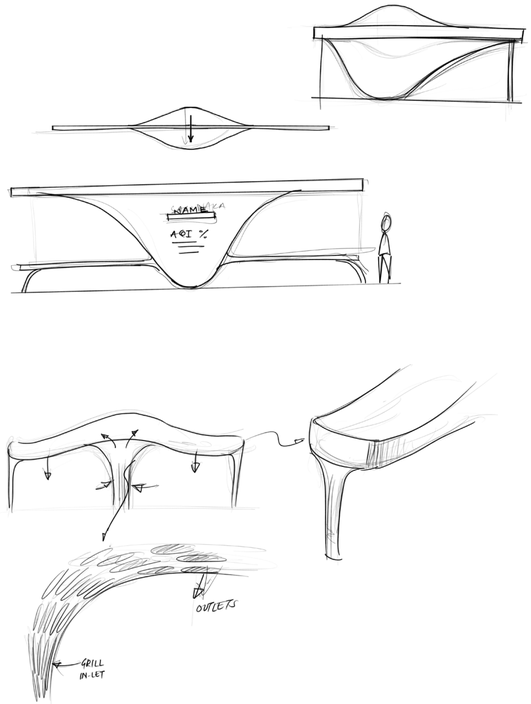


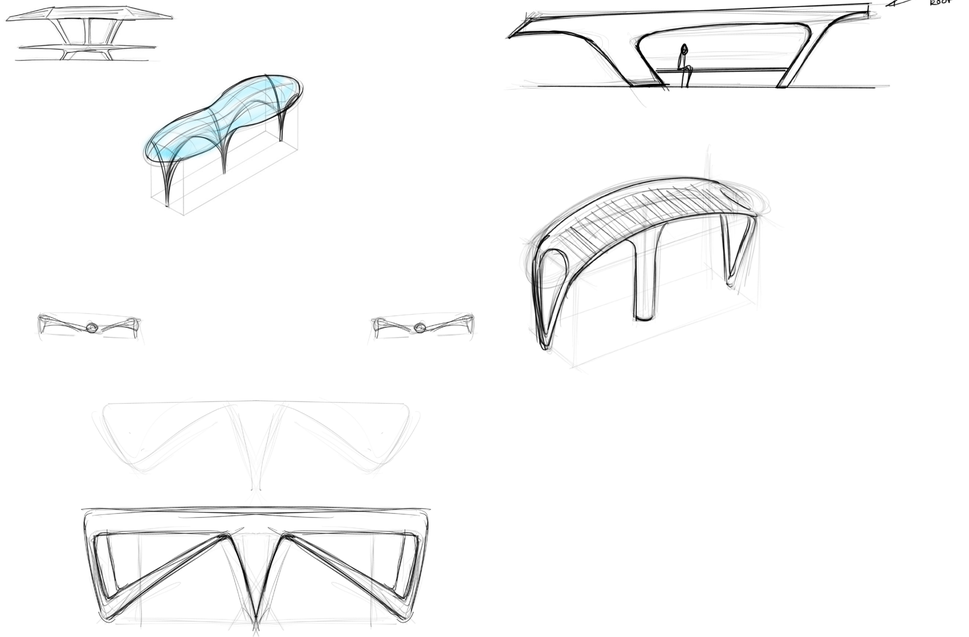


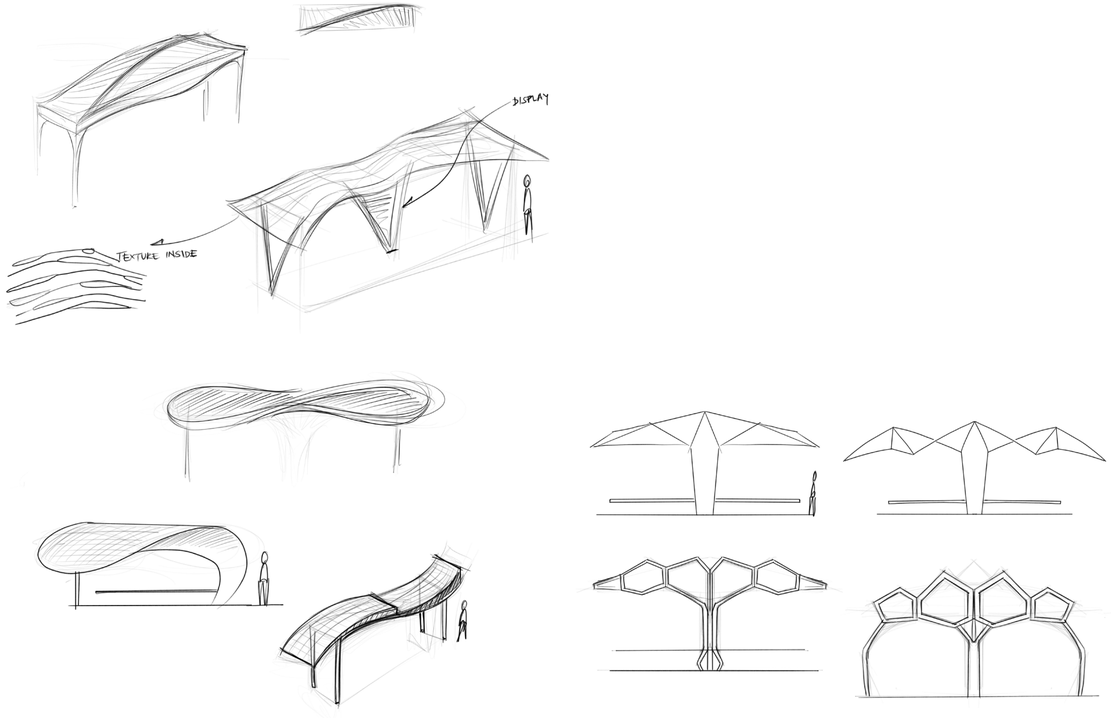

DIFFERENT
WAYS TO ARRANGE
PILLARS
PILLAR


AIR
PURIFIER
OUTLETS

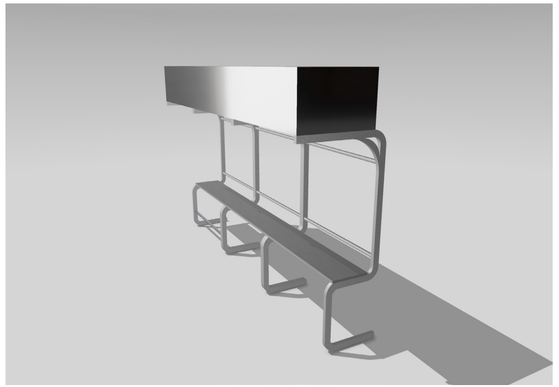

AQI DISPLAY
SEATING

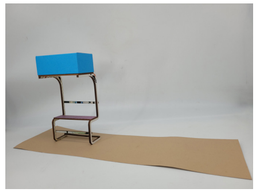

NAME
AQI %
OUTLETS
GRILL
IN-LET

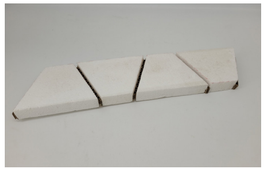

SLANT ROOF

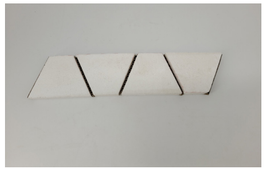

DISPLAY
TEXTURE INSIDE

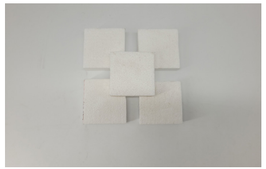
Modular bus stop units





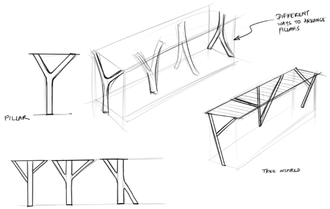


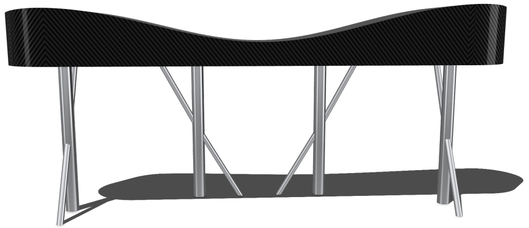


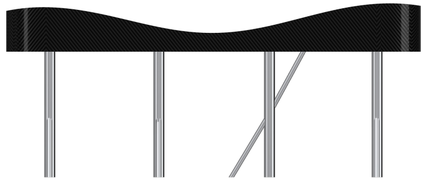


Concept Ideas

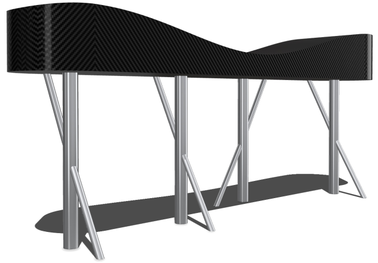
01

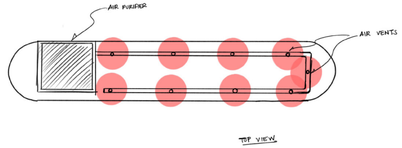






orientation of pillars in form of branches
can be rearranged





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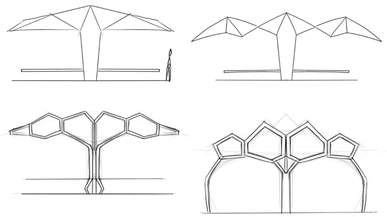

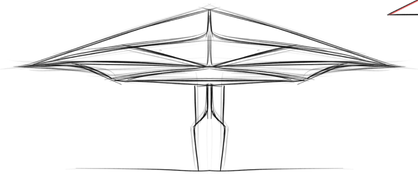

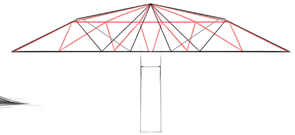

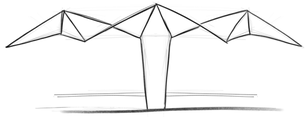

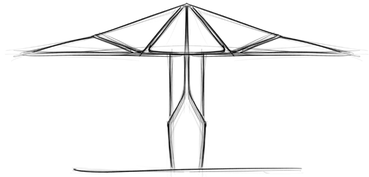

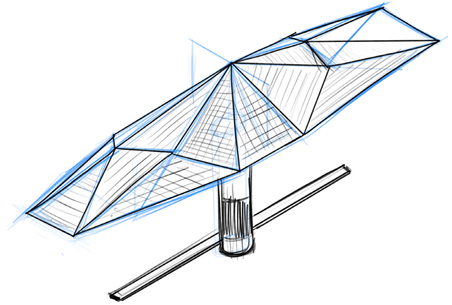

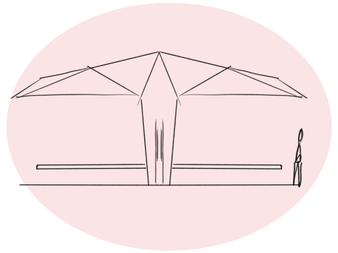

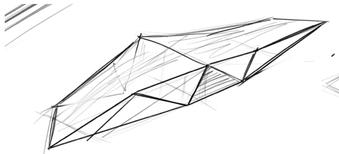

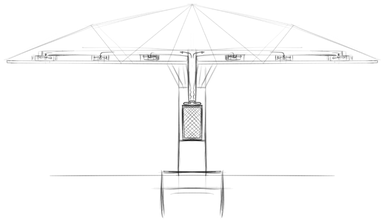

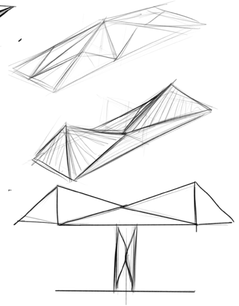

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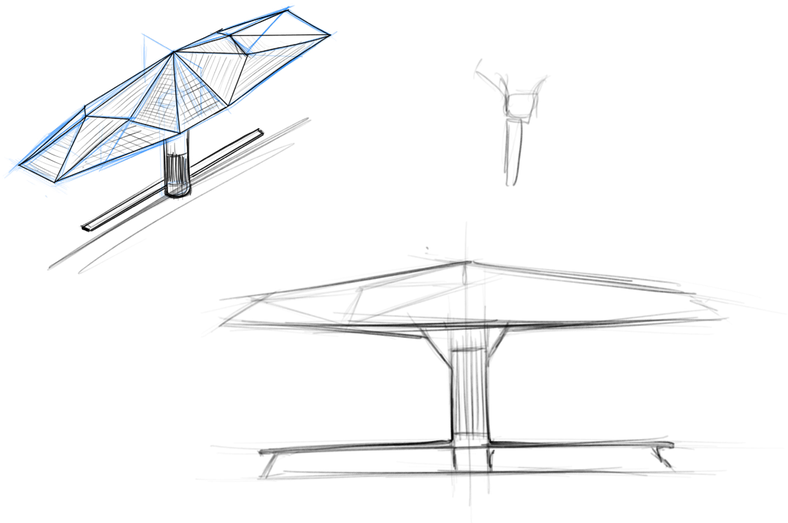
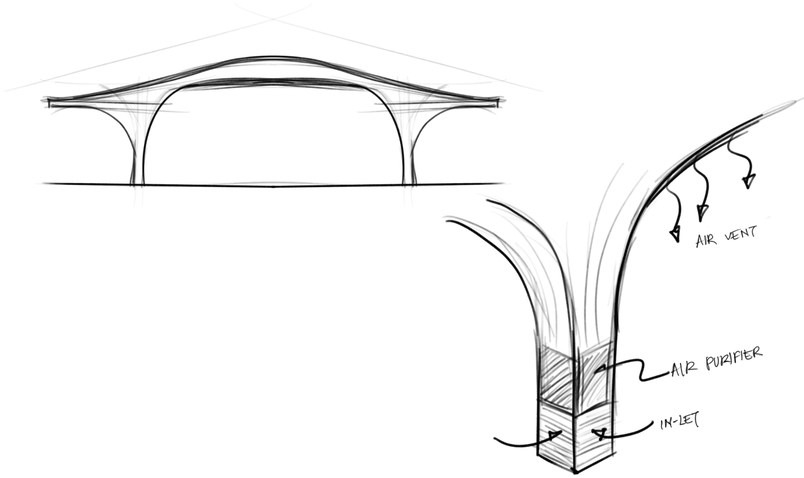
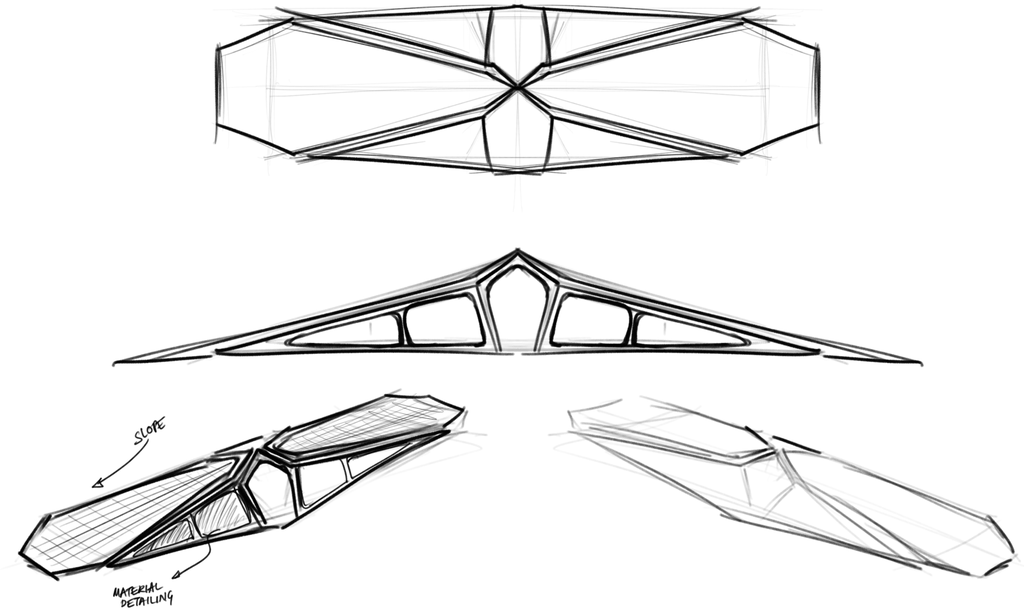
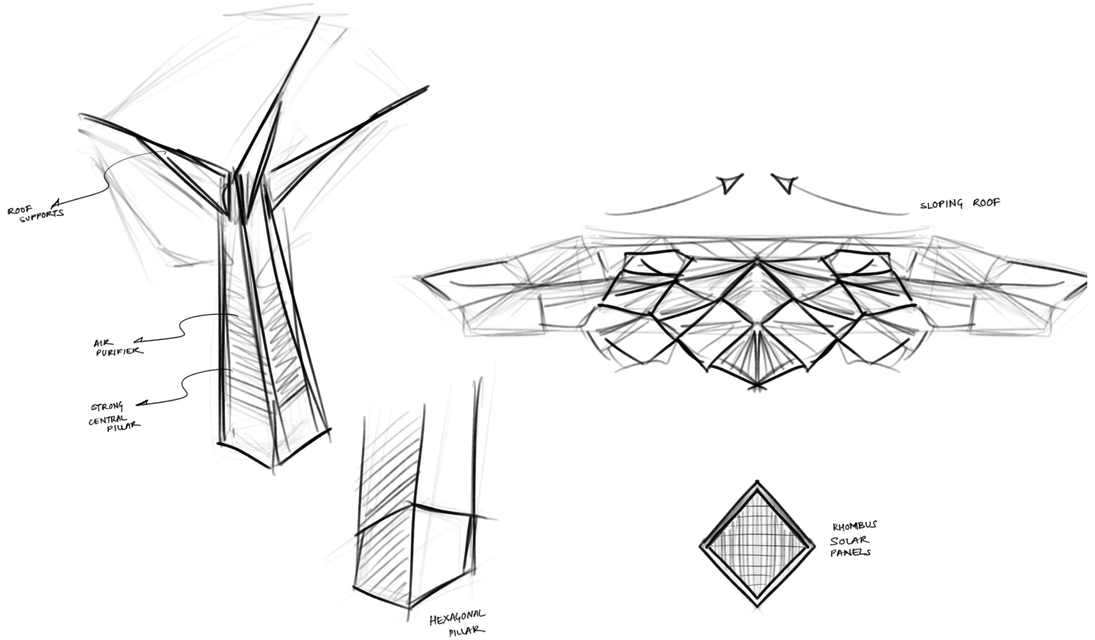
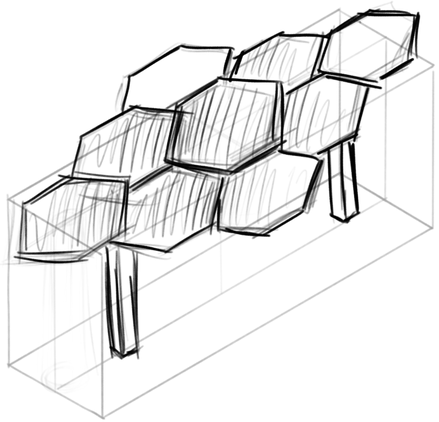
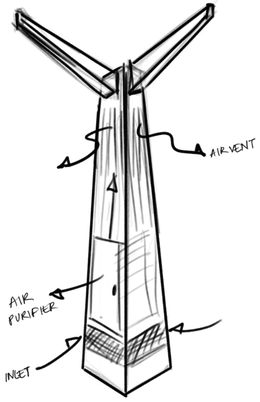


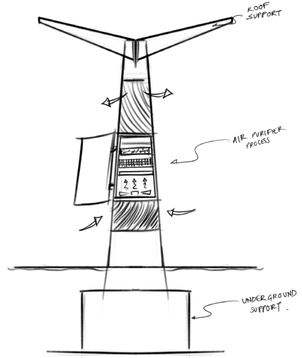


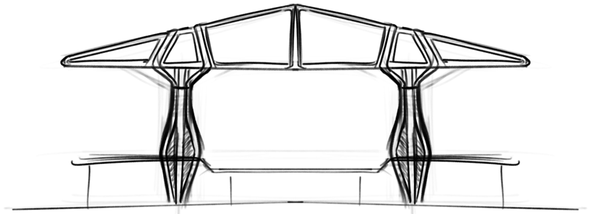

SLOPE
MATERIAL DETAILING

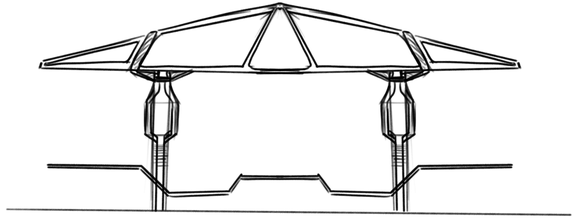

ROOF SUPPORTS
AIR PURIFIER
STRONG CENTRAL PILLAR
HEXAGONAL PILLAR
SLOPING ROOF
RHOMBUS SOLAR PANELS

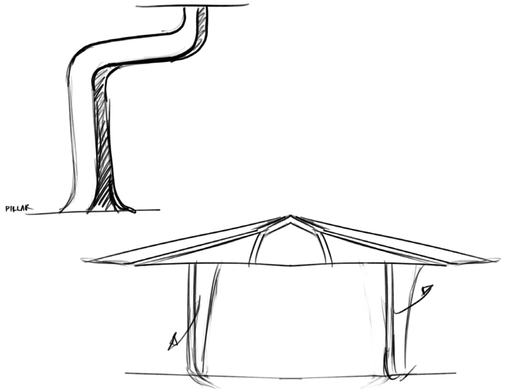


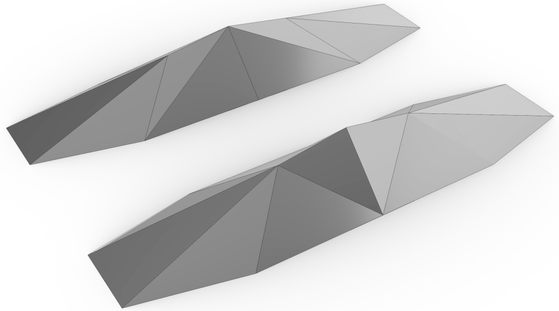

AIR VENT
AIR PURIFIER
INLET

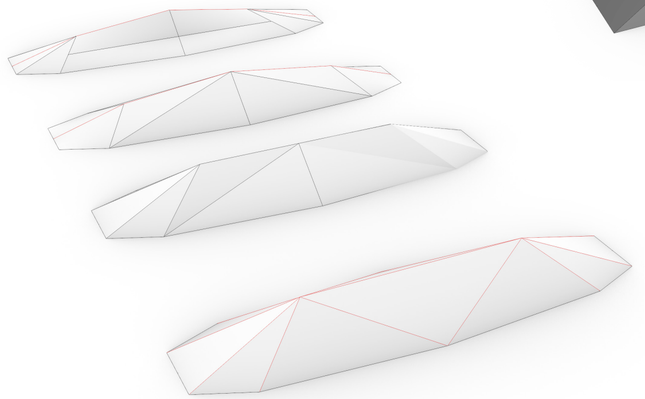

ROOF SUPPORT
AIR PURIFIER PROCESS
UNDERGROUND SUPPORT

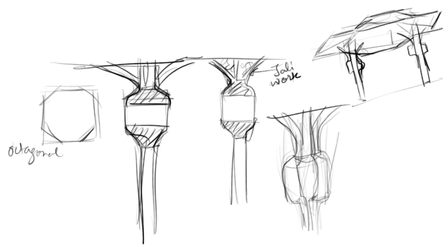


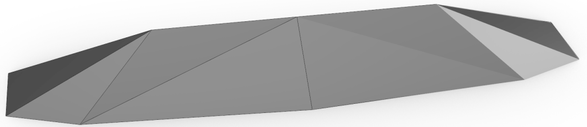


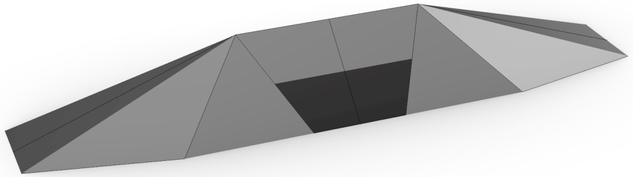

PILLAR

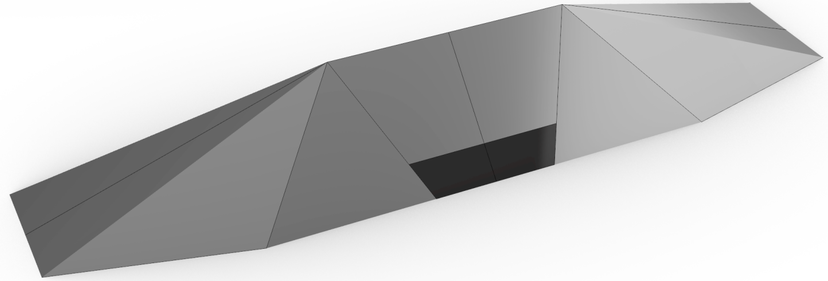




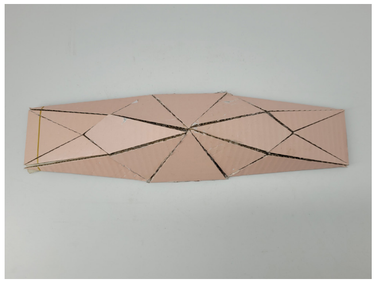

Tabi
work
octagonal

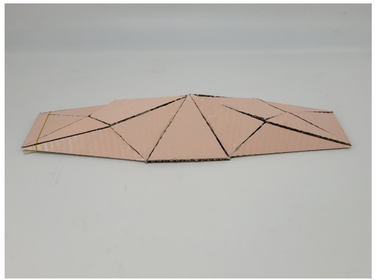


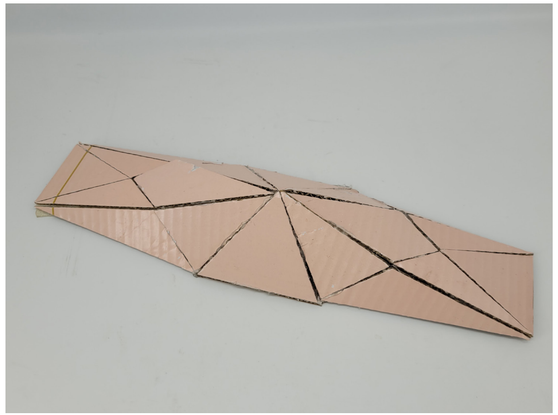


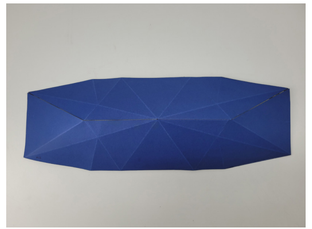


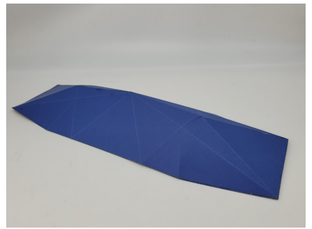
Mock-ups of form

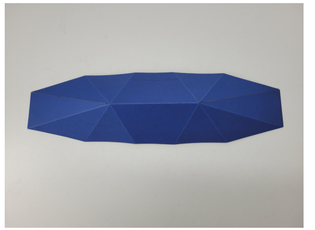


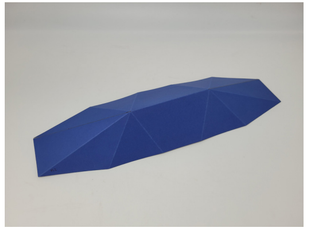


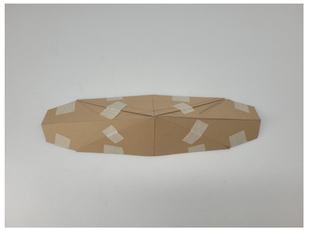




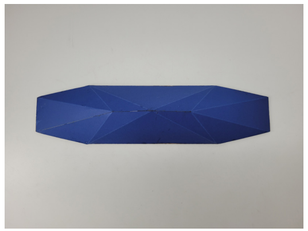


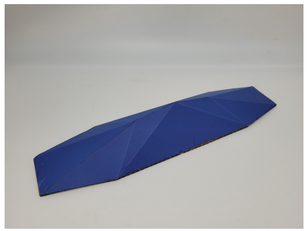


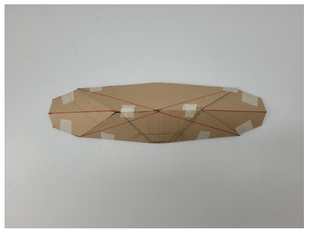


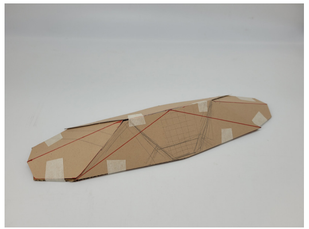


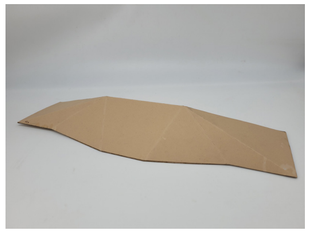
Mock-ups of form

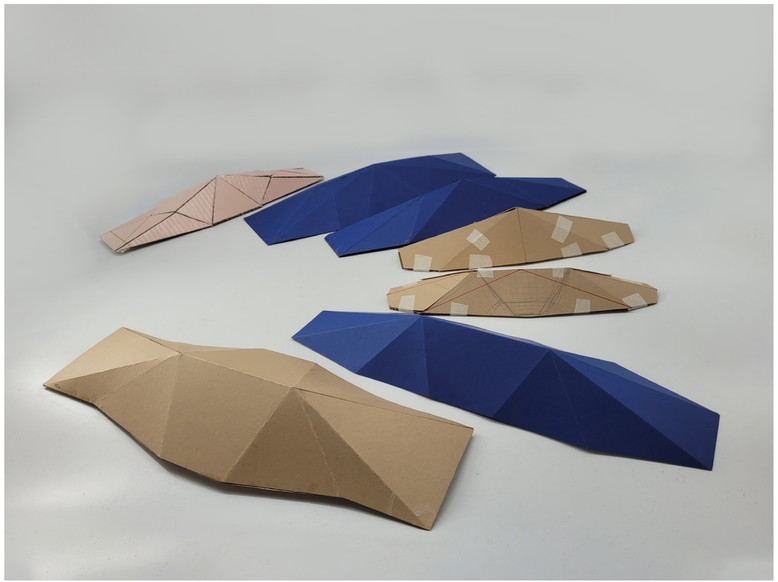




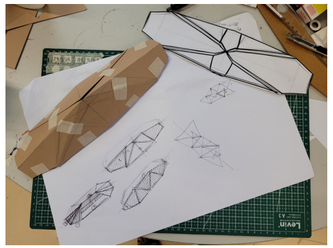






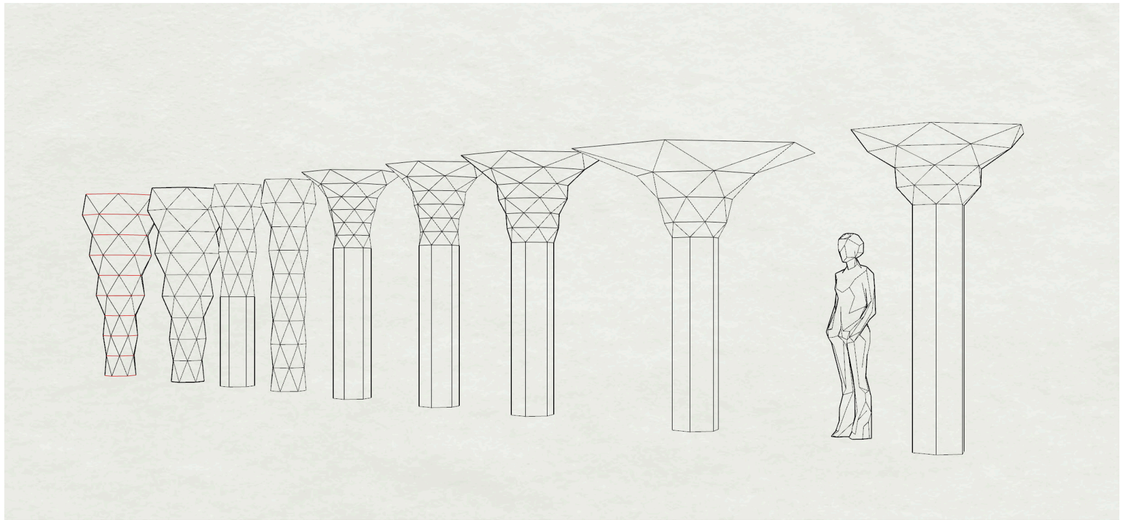


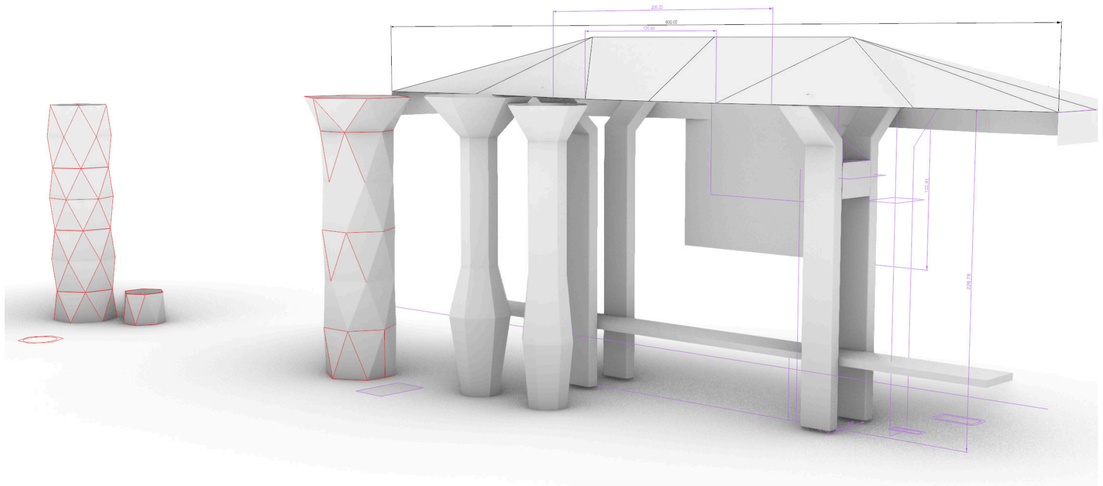
A scaled mockup with ceiling length of 40 cms was made to study its proportions with the pillar body.

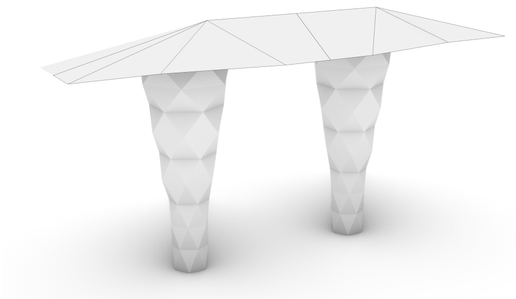


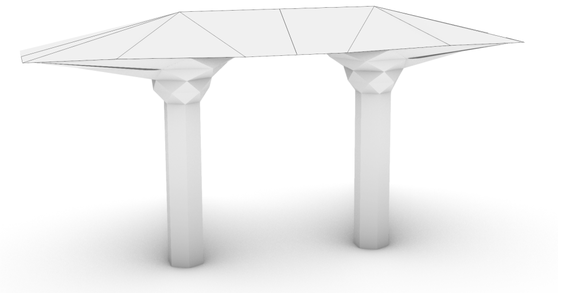
After numerous iterations and mockups, the final form of the design was determined, taking into account both design aesthetics and functionality. The process involved careful evaluation and refinement to ensure that the final form met the desired objectives and delivered an optimal user experience.
Throughout the iterative design process, various design options were explored and evaluated. Feedback from stakeholders and user testing played a crucial role in shaping the final form. Design aesthetics were carefully considered to create an appealing and visually pleasing product that aligns with the intended user experience.
Functionality was a key consideration during the design iterations. The final form was chosen based on its ability to effectively perform the intended functions and meet the desired requirements.
With the final form decided, the focus can now shift to the implementation and realization of the design. The design team can proceed with translating the final form into a tangible product, ensuring that the aesthetics and functionality are seamlessly integrated to deliver a successful end result.

3d iterations of bus stop

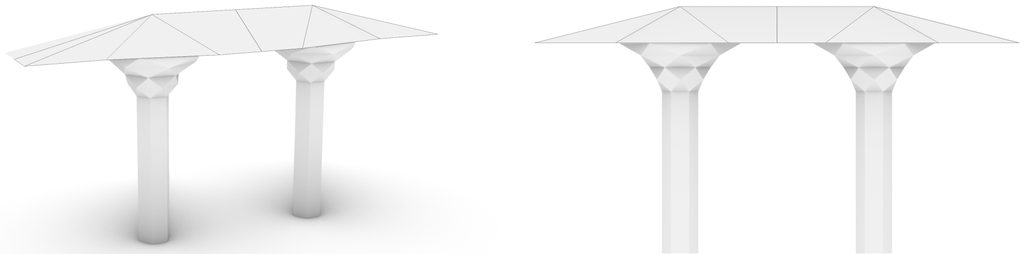




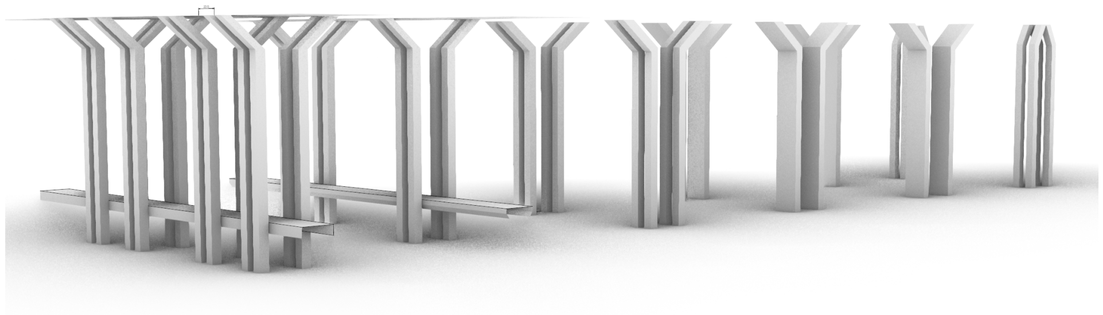


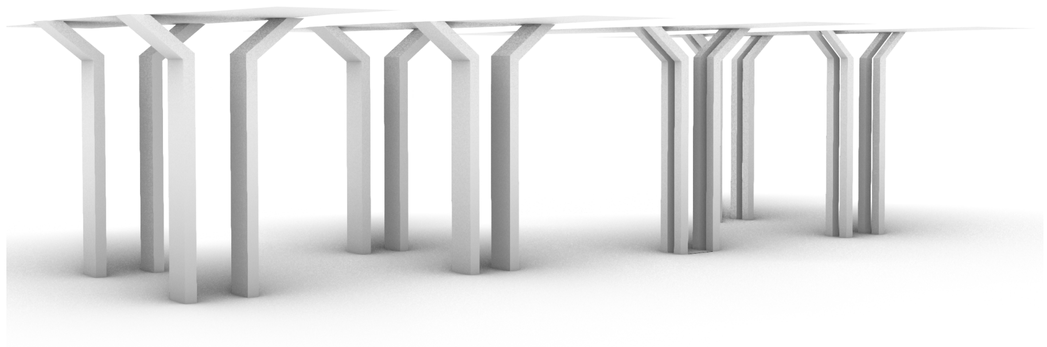


Initial final concept

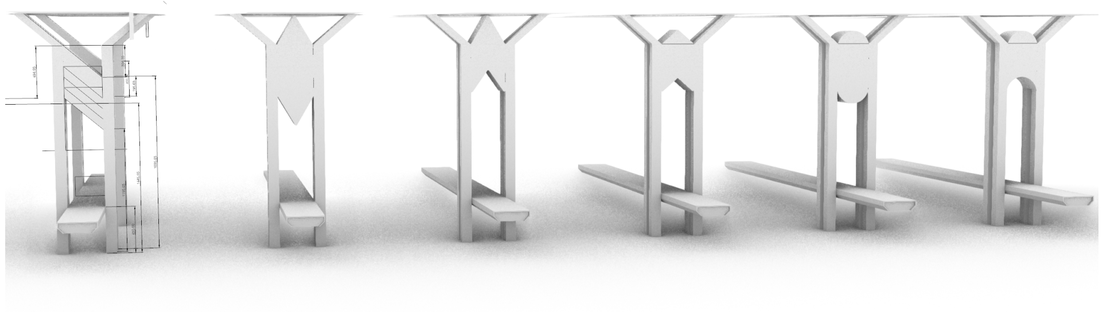


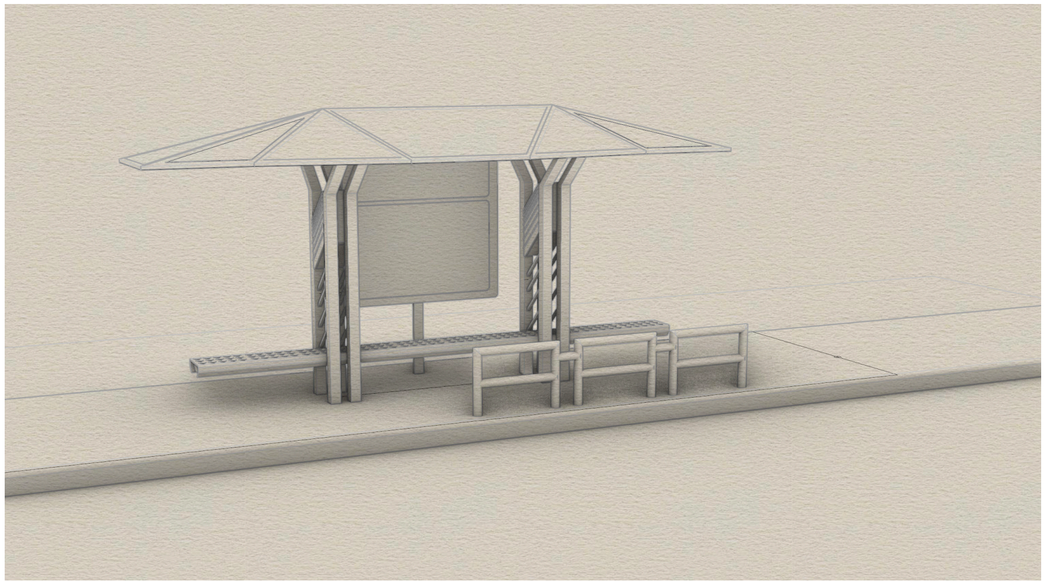
Redirecting design ideation

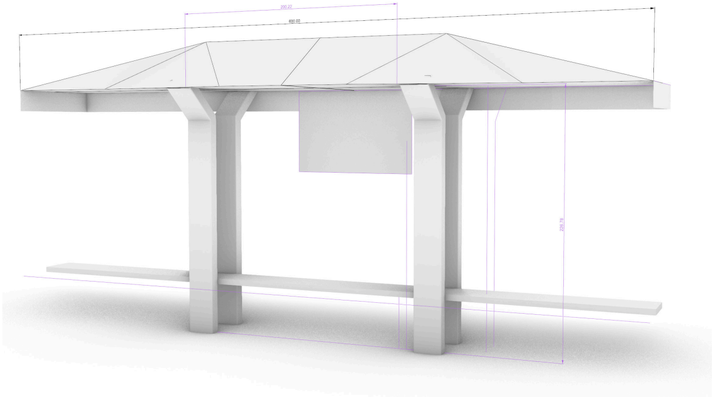




Air purifier and bench ideation







Branding

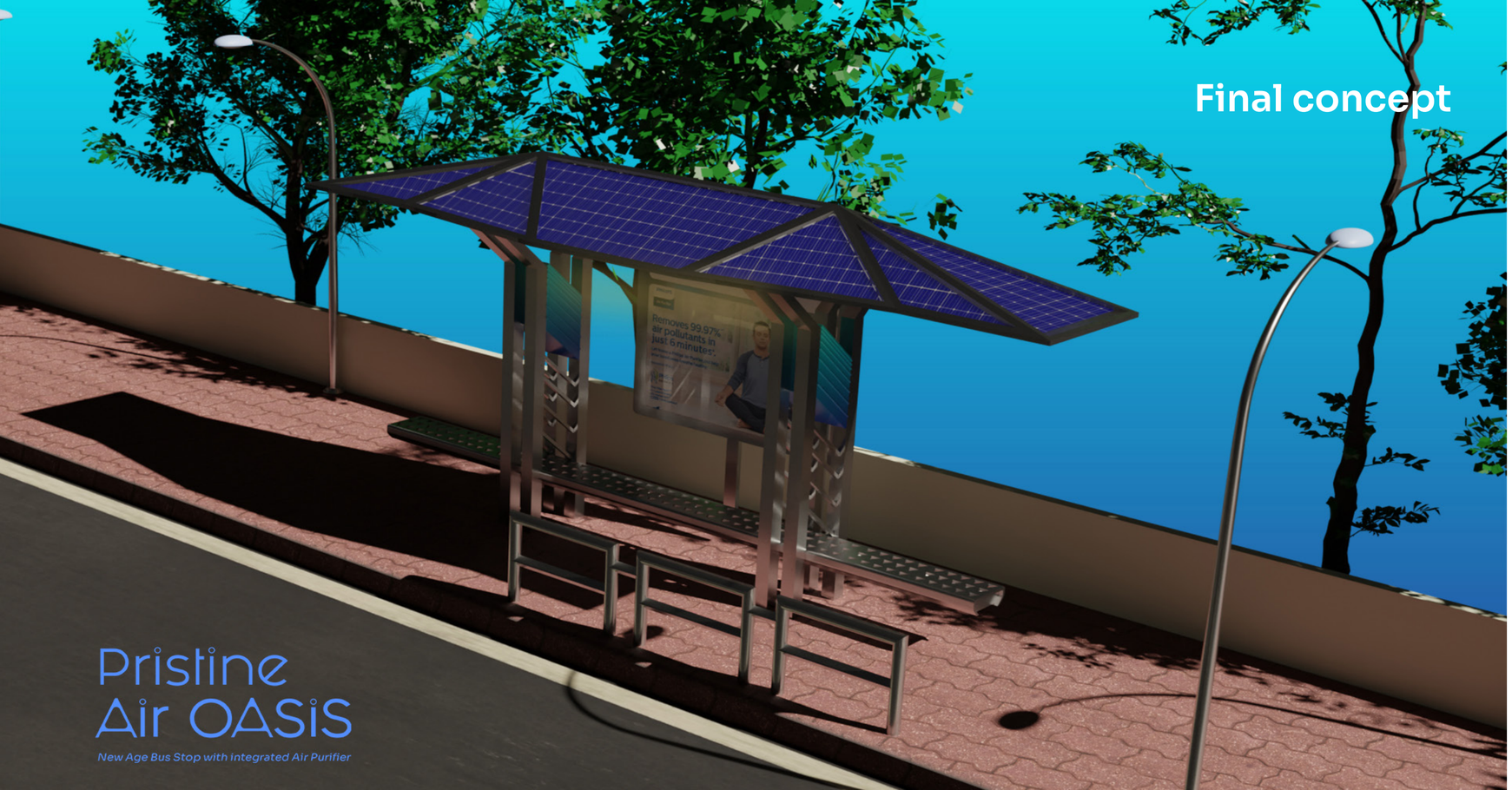
Branding

Symbols

colour palette

Pristine
Air OASiS

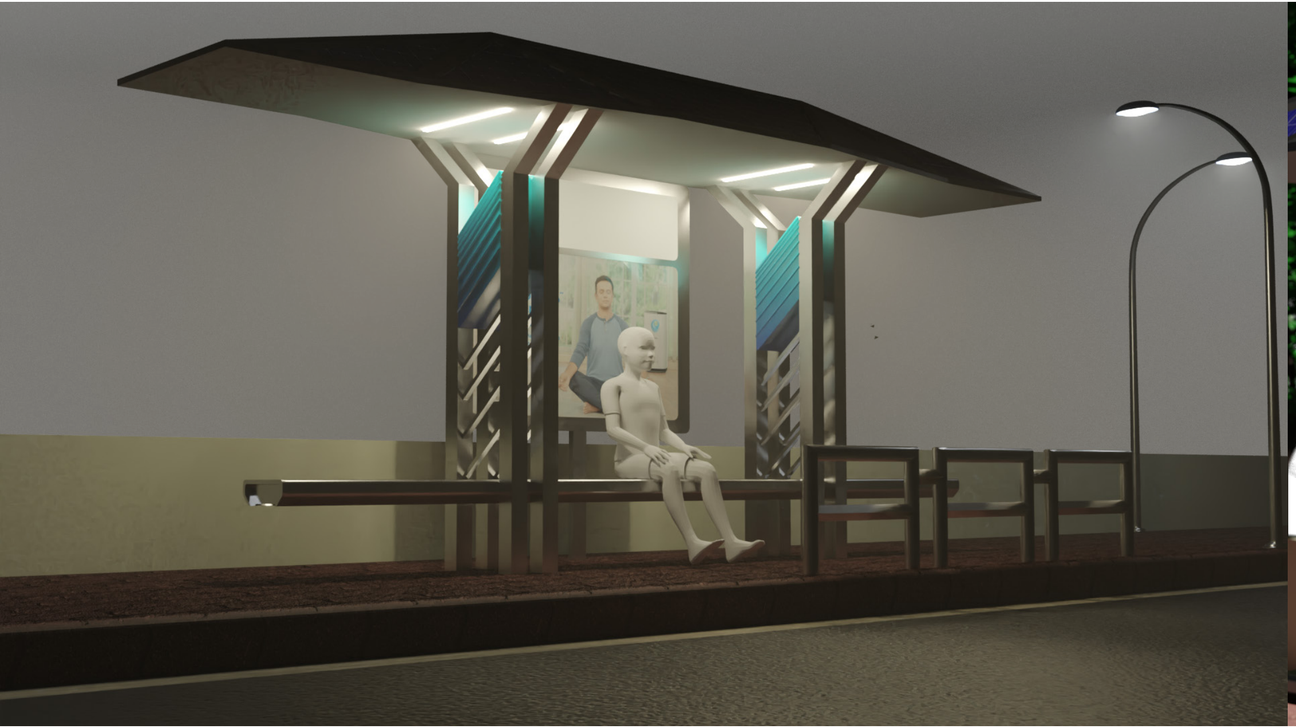
New Age Bus Stop with integrated Air Purifier



Final concept

Pristine
Air OASiS

New Age Bus Stop with integrated Air Purifier

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Air Purifier
Removes 99.97%**
air pollutants in
just 6 minutes*.
Get home a Philips Air Purifier and help
your loved ones breathe healthy.
Philips


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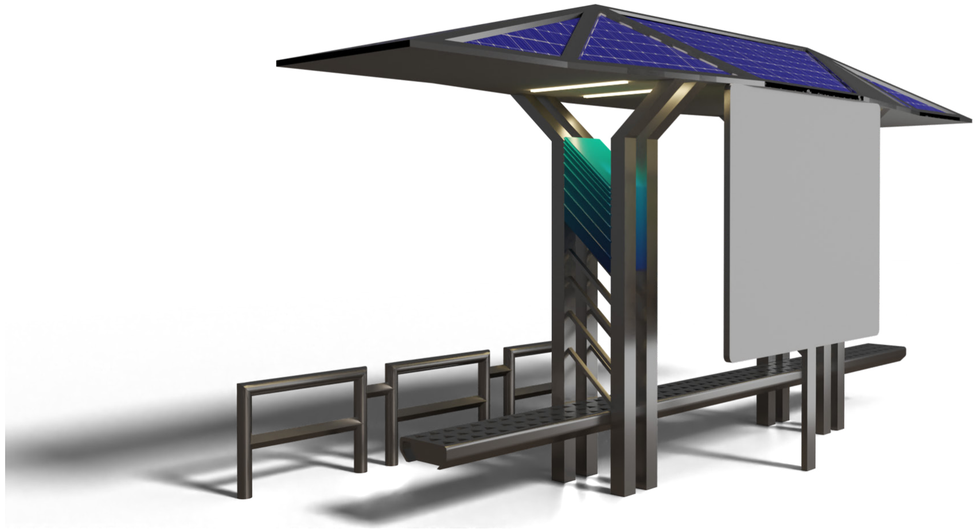
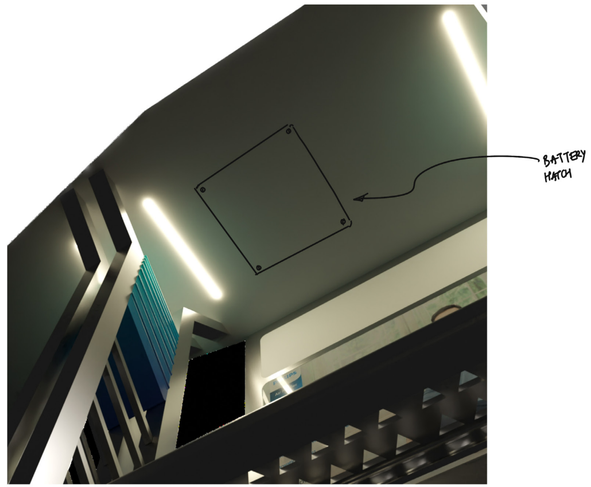
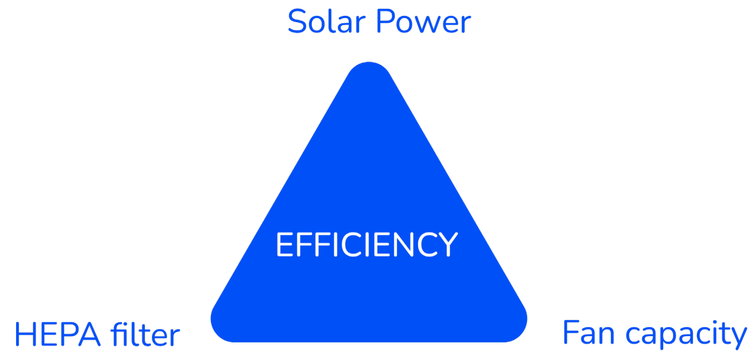
innovation + you
Philips
KACHAUKA

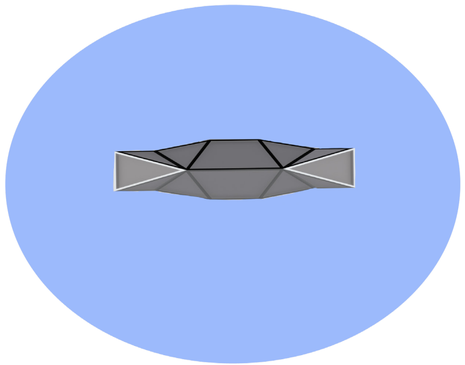




Technical specifications



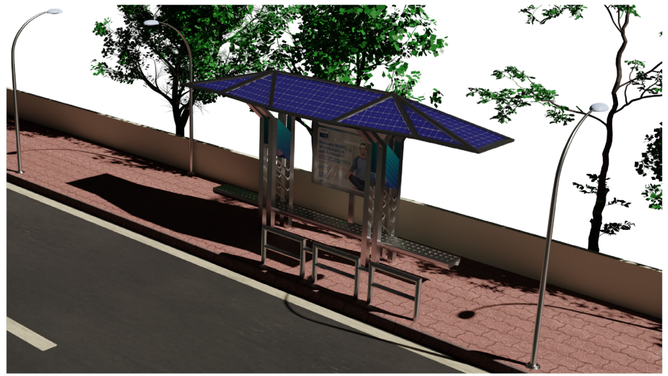
Range of purifier



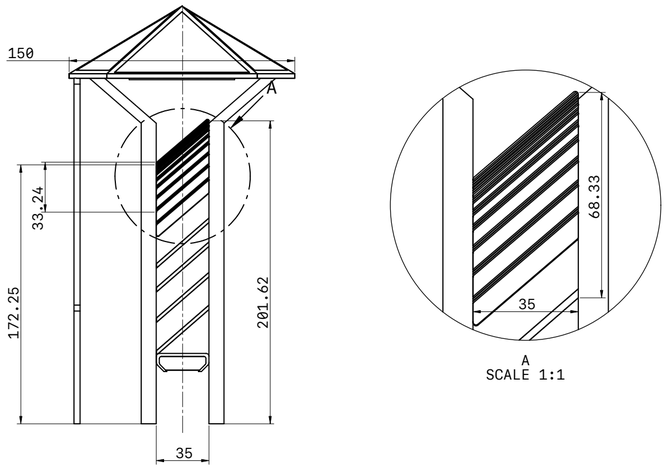
Radius of 20 mt

Technical specifications

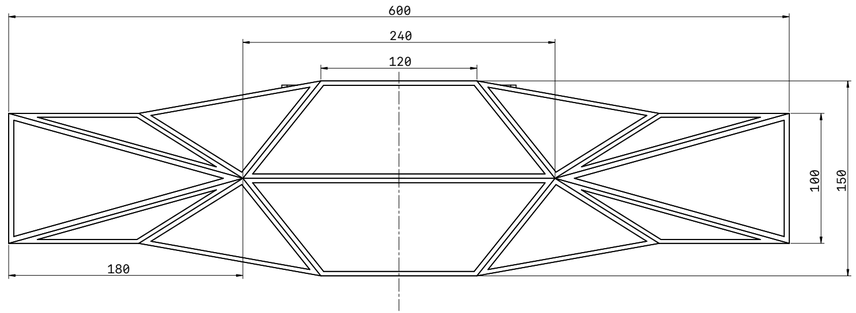
- Radius of effect 40 mt
- Height is 4.5mt
- Volumetric figure around 12500m³
- Exhaust effeciency: CFM = 250
- Fan RPM 2050
- 1.25 hr every cycle



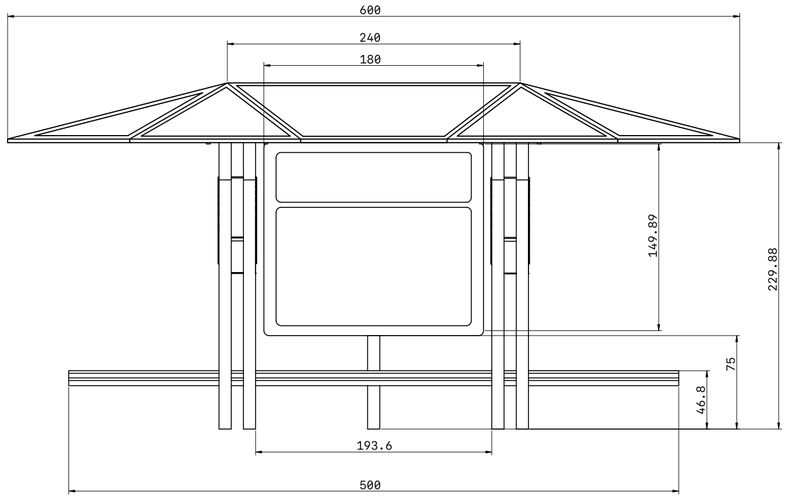
Technical details



Side view



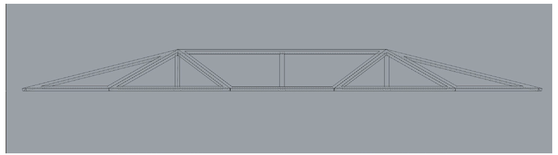
Top view

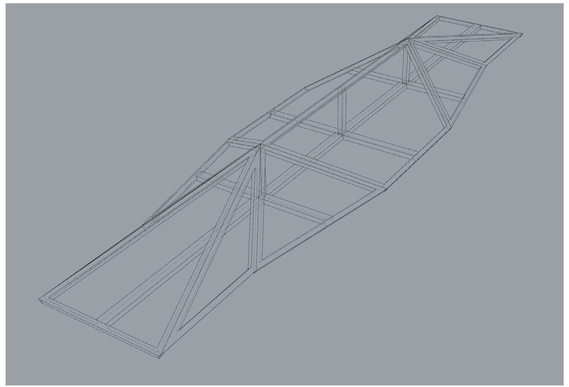


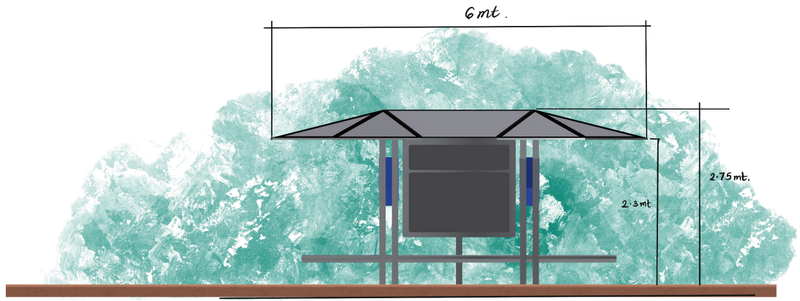
Front view

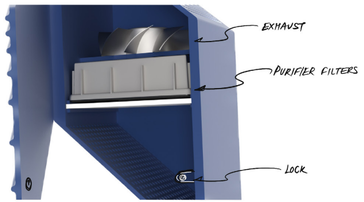
Installation in major cities of India

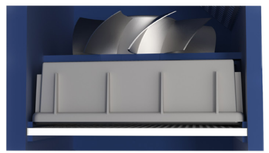
Structure of roof



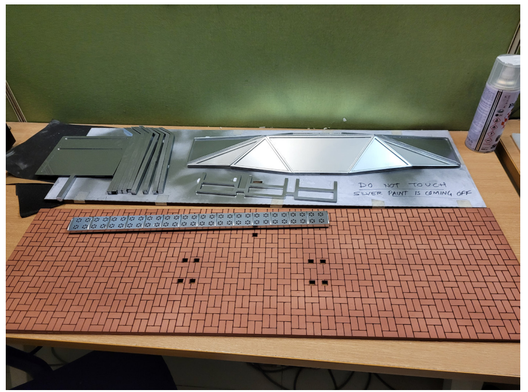






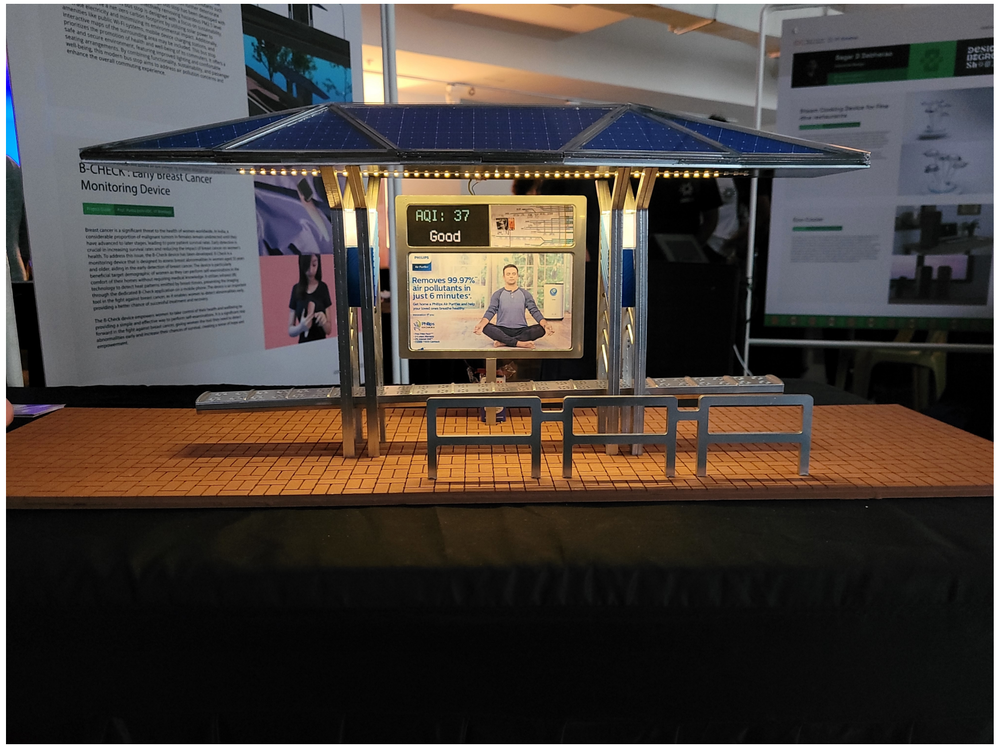


Prototype in making



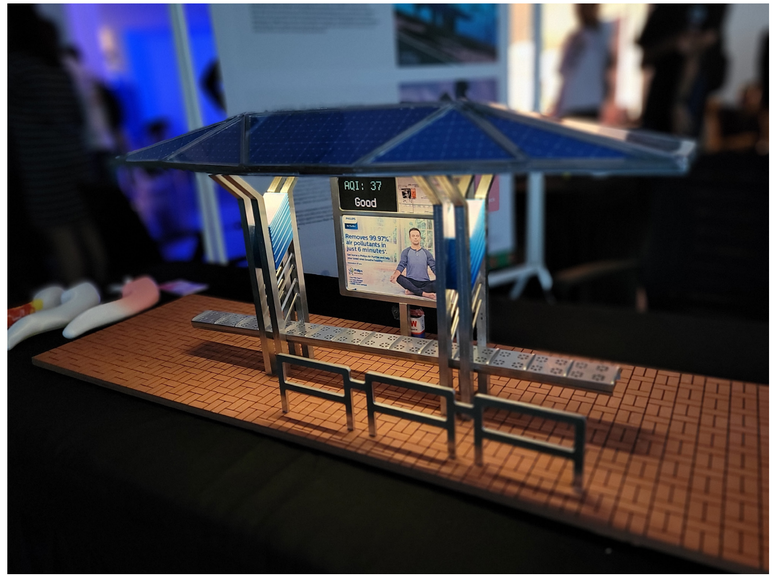
Prototype


AQI: 37
Good
Removes 99.97% air pollutants in just 6 minutes*


B-CHECK : Early Breast Cancer Monitoring Device
AQI: 37
Good
Removes 99.97% air pollutants in just 6 minutes*


AQI: 37
Good


AQI: 37
Good


AQI: 37
Good

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AIR purifier tower china

THANK YOU

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