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Scuola Del Design

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Design & Engineering

Air Things

A new solution for the reduction of indoor air pollution.

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Abstract

Today the indoor air pollution is become a serious problem which involves the whole World.
The negative and heavy impact of human society on the environment has been demonstrated by several studies.
The necessity of finding useful and operational solutions is imminent in order to guarantee a better quality of human life, that otherwise will continue to gradually worse.
For this reason, it is important to improve the methodologies of the air quality monitoring through the use of new models and measurements.
Following the previous considerations, this master thesis wants to challenge today's air monitoring system trying to propose new solutions tailored on real users needs.
The purpose of this thesis is to develop a new air quality monitor that can detect an excess of pollutants and, relying on established technologies, improve the quality of the indoor air, using the potential of air treatment devices.
A profound study has been carried out regarding pollutants and how these can affect the state of health, from which it follows that a high concentration of PM2.5, VOC, CO_2 and CO can affect the state of health.

Abstract (ita)

Oggi l'inquinamento dell'aria domestico è divenuto un serio problema che riguarda tutto il mondo. Il negativo e pesante impatto della società umana sull'ambiente è stato dimostrato da diversi studi. La necessità di trovare soluzioni utili e funzionali è imminente per poter garantire una migliorare qualità di vita, che inevitabilmente continuerà a peggiorare. Per questa ragione è importante cambiare la metodologia con la quale oggi avviene il monitoraggio dell'aria, attraverso l'uso di nuovi modelli e misurazioni.

In seguito alle precedenti considerazioni, questa tesi magistrale vuole mettere in discussione l'odierno sistema di monitoraggio dell'aria per cercare di proporre nuove soluzioni costruite sui reali bisogni degli utenti.

Lo scopo di questa elaborato è quello di sviluppare un nuovo monitor di qualità dell'aria in grado di individuare un eccesso di agenti inquinanti e, basandosi sulle conosce consolidate della tecnologia, migliorare la qualità dell'ambiente domestico utilizzando il potenziale dei dispositivi per il trattamento dell'aria.

É stato realizzato un profondo studio a riguardo degli agenti inquinanti e come questi possano condizionare lo stato di salute, dal quale ne deriva come un alta concentrazione di i PM2.5, VOC, CO_2 e CO possano condizionare lo stato di salute.

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Design Research

The first phase of thesis development was to explore and analyze how indoor pollution is evolving and how people are adapting to this problem.

Figure 1.1: Pollution in our days

Air Pollution in our changing word

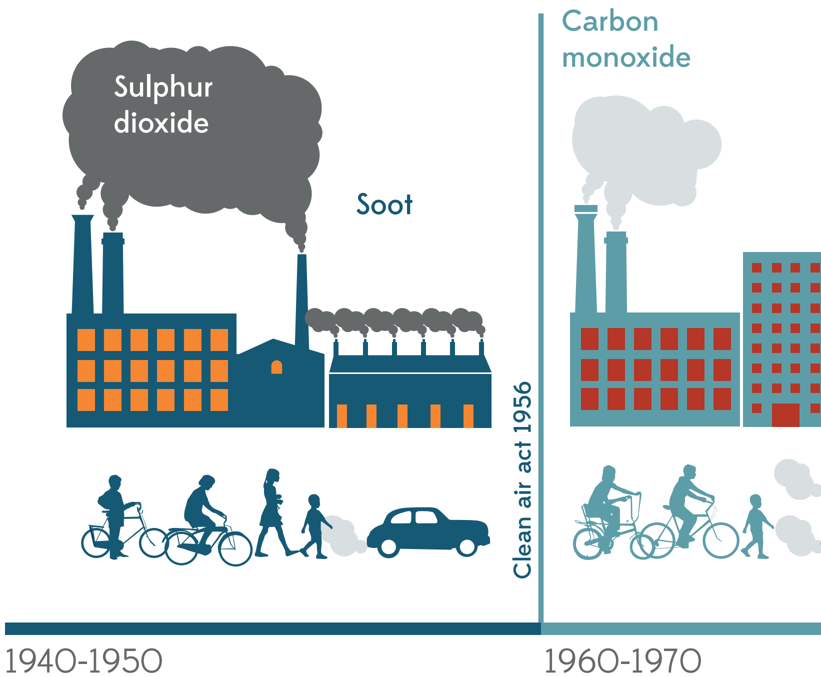
The air pollution is become a global concern. It has been proved that human society is directly responsible of the increase of pollutant emissions on the atmosphere. The massive scale of urbanization, the increase of trac, the industrialization and the energy consumption are the main causes of the air quality worsening. It is true that new technologies, as new generation engines, decrease or eliminate harmful pollutants.

Air pollution is not a new problem. If we remember the London smog of 1952 that killed 12,000 people. Since then, changes in the way we live have also changed the air pollution that we breathe. Coal burning has fallen dramatically, but today increased road transport and the failure to control some exhausts from diesel vehicles has led to us being exposed to new air pollutants.

Looking at different generations tells the story. As children, today's grandparents were exposed to soot and sulphur dioxide from coal burning. Those now in middle age breathed in emissions from leaded petrol. Today's children walk and cycle much less, and they inhale nitrogen dioxide and the tiny particulates from diesel-fuelled vehicles.

Around the world, there are many examples where reducing air pollution has improved public health. It now seems likely that childhood exposure to air pollution has a lasting influence on health, so the gains from tackling air pollution

> **Nowadays the sky over many cities and megacities are rarely blue. While the color blue could not be considered as a direct indicator of the cities air quality**

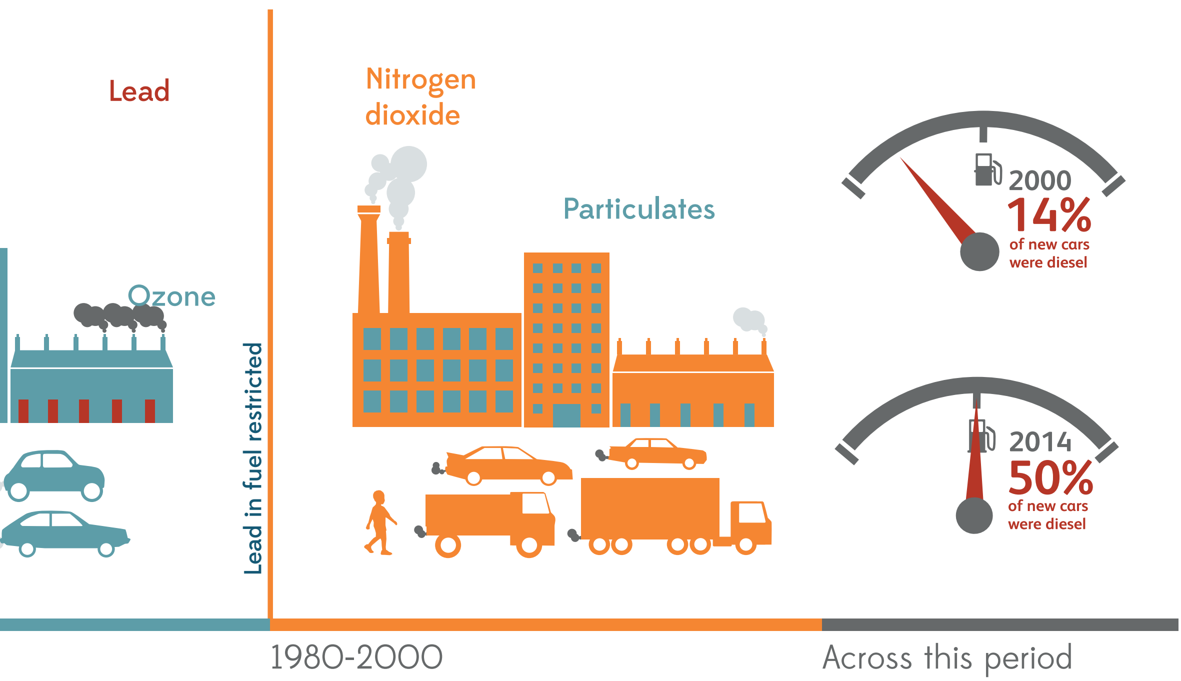


today will be felt throughout the decades to come.

Today life is very different from how it was in the 1950s. Much more than legislation has changed since this time, with various social, fuel and technology transitions driving a huge change in outdoor air pollution – changing old pollution sources and introducing new hazards into our breathed environment. Concerns about black smoke and air acidification (sulphur dioxide, SO2) from coal burning have been replaced by new concerns about particle pollution and nitrogen dioxide (NO2) from transport, and the air pollution that forms through chemical reactions between other pollutants in the atmosphere. With new knowledge that pollutants can remain in the air for days or even weeks, air pollution has moved from being a local problem to one that requires source control at city, regional and even international scales.

Nevertheless, certain phenomena as the exponential growth of vehicle number does not allow to reduce the emissions (Molina et al., 2004).Nowadays the sky over many cities and megacities are rarely blue. While the color blue could not be considered as a direct indicator of the cities air quality, the absence of it is a clear warning sign related to the level of air pollution. All around the world, the cities might be considered as the protagonists in the air pollution issue. In fact, a mega pollution source is constituted by the cities themselves.

Chart 1.1: Evolution of air pollution



What is Air Pollution?

Air pollutants can be gas, solid particles, or liquid. They can be the result of the production of natural processes or human activities. The natural sources of air pollutants include volcanic activity, forest fires, organic decay or soil dispersion into the air by the wind and those pollutants creates the basic level of pollution that is perfectly natural and can be absorbed by the environment. "Air pollution is the introduction into the atmosphere of chemicals, particulates, or biological materials that cause discomfort, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment" .
United States Environmental Protection Agency.
Pollutants are classified as primary or secondary. Primary pollutants are a direct result of a process, such as ash from a volcanic eruption, carbon monoxide gas from motor vehicle exhaust, or the sulphur dioxide released from factories.
Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact; smog created by the interactions of several primary pollutants is known to be as secondary pollutant.
There are two diverse sources of air pollution: natural sources and man-made sources.

In recent years, a large proportion of emissions has shown significant absolute decoupling from economic activity, which is desirable for both environmental and productivity gains. This is indicated by a reduction in EU-28 air pollutant emissions contrasting with an increase in EU-28 GDP (Eurostat, 2018a), which effectively means that there are now fewer emissions for each unit of GDP produced per year. The greatest decoupling has been for SOx, CO, NOx, certain metals (Ni, Pb, Cd, Hg) and organic species (NMVOC and BC), for which emissions per unit of GDP were reduced by over 50 % between the years 2000 and 2016. A decoupling of emissions from economic activity may be due to a combination of factors, such as increased regulation and policy implementation, fuel switching, technological improvements and improvements to energy or process efficiencies.

01.

NATURAL SOURCES OF POLLUTION

It include dust carried by the wind, gases released from the body processes of living beings (Carbon dioxide from humans during respiration, Methane from cattle during digestion, Oxygen from plants during Photosynthesis). Smoke from the combustion of various inflammable objects, volcanic eruptions, etc.

02.

MAN-MADE SOURCES OF POLLUTION

Theu include smoke emitted from various forms of combustion like in bio mass, factories, vehicles, furnaces, etc.

“

Air pollution is the introduction into the atmosphere of chemicals, particulates, or biological materials that cause discomfort, disease, or death to humans

United States Environmental Protection Agency.

Chart 1.2 : Percentage of the urban population in the EU-28 exposed to air pollutant concentrations above certain EU and WHO reference concentrations Air quality EEA

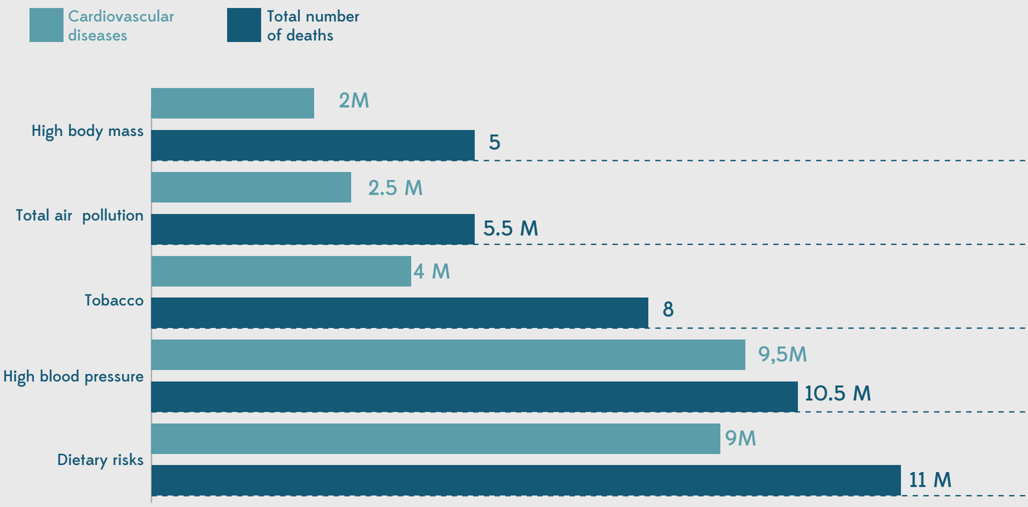
Pollutant	EU reference value	Exposure estimate (%)	WHO AQG	Exposure estimate (%)
PM 2.5	Year (25)	6-8	Year (10)	74-85
PM 10	Day (50)	13-19	Year (20)	42-52
O 3	8-hour (120)	7-30	8-hour (100)	95-98
NO 2	Year (40)	7-8	Year (40)7	7-8
BaP	Year (1)	20-24	Year (0.12) RL	85-90
SO2	Day (125)	< 1	Day (20)	21-38

Key				
Key	< 5 %	5-50 %	50-75 %	> 75 %

The last report of the European Environment Agency, (EEA, 2018), presents an updated overview and analysis from 2000 to 2014 based on data from social monitoring stations across Europe, including more than 400 cities. According to it, in 2014, 85% of urban population was exposed to PM2,5 at levels considered dangerous to health by the World Health Organization (WHO). Different researches have demonstrated that PM2:5 could cause or aggravate cardiovascular diseases and lung cancer. Moreover, in 2013 the exposure to PM10 was responsible of 467 000 premature deaths in 41 European countries while the NO2 and the ground level of O3 have been respectively the cause of 71 000 and 17 000 premature deaths in Europe. The study of Lim et al (2013) found that household air pollution from solid fuels remains one of the three leading risk factor for global disease burden. This research evaluated the death and disability adjusted life years (DALYs), which is the sum of years lived with disability and years of life lost, attributed to the independent effects of 67 risk factors and cluster of risk factors for 21 regions in 1990 and 2010. Whereas in 1990 the household air pollution represent the 4,3% off global DALYs, it is increased up to 6,8% in 2010.

In one of the last WHO reports (Pruss- Ustun et Corvalan, 2016) emerges the needed of a healthy environment to improve the prevention of several diseases. In fact, the document points out that 12.6 millions deaths are due to environmental factors. It represents the 23% of World's deaths in 2012. This negative health impact is highlight also by The International Agency for Research on Cancer, which has classified air pollution in general as carcinogenic.

Chart 1.3: Burden of disease attributable to 20 leading risk factors in 2010, expressed as a percentage of global disability-adjusted life-years



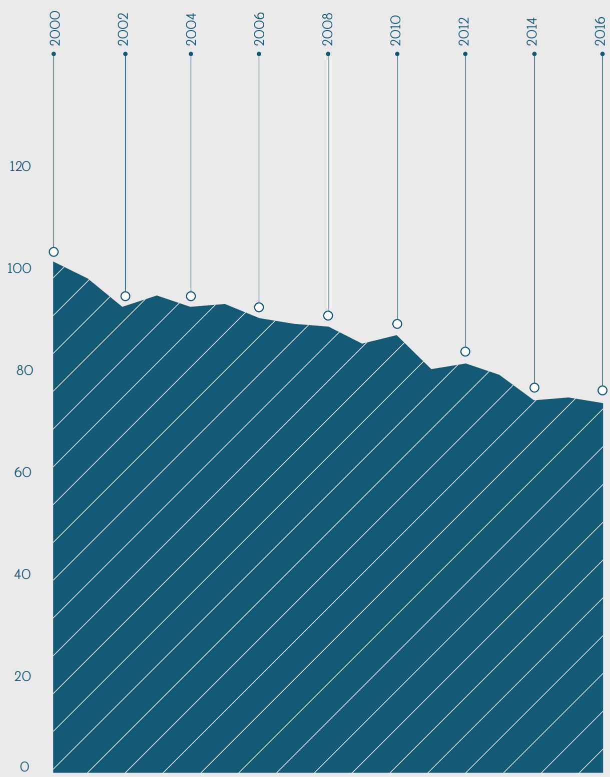
85% of urban population

was exposed to PM2,5 at levels considered dangerous to health by the World Health Organization.

23% of World's deaths in 2012

are due to environmental factors. This negative health impact is highlight also by The International Agency for Research on Cancer,

Chart 1.4: Development in EU-28 emissions, 2000-2016 (% of 2000 levels)



Sources and emissions of air pollutants

The main pollutants released in the atmosphere related to human activity come from transportation, burning coal or other fossil fuels in order to satisfy the electric energy demands, industrial processes, use of chemicals in agriculture and process, facilities like power plants, incinerators, landfills for waste deposition.

“The major outdoor air pollutants produced by human activities include, among others

• Carbon oxides, especially carbon monoxide (CO) and carbon dioxide (CO2) produced by the transportation sector (motor vehicle exhaust) and combustion of fossil fuels;

• Nitrogen oxides, especially nitrogen dioxide (NO2) emitted from hightemperature fossil fuel combustion and electricity production;

• Sulphur oxides, produced in various industrial processes such the smelting of sulphur-bearing ores for extracting metals and electricity production;

• Volatile organic compounds (hydrocarbons, VOCs) that include a variety of substances released from power plants and from industries producing numerous products such as painting colours, cleaning products, 15 pesticides, building materials, and furniture;

• Particulate matter (PM), that is solid or liquid air pollutants mainly emitted by power plants and the transportation sector (aircrafts, motor vehicles), mining, and incinerators;

• Ground level ozone (O3), an air pollutant that results from photochemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight;

• Toxic metals particularly lead (Pb), cadmium (Cd) and cooper (Cu) that are emitted from the transportation sector (motor vehicle exhaust), as well as from industrial procedures (production of painting colours, mining processes).

Increasing population in urban areas results in increasing demands in transportation, industrial production and energy, which constitute the main sources of outdoor air pollution. Moreover, this problem is intensified due to inadequate green open spaces in towns and cities and their restricted possibility to improve air quality and reduce air pollution”. (Dimitriou, Christidou, 2011)

The main causes of air pollution are:

Burning of fossil fuels: sulphur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one the major cause of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of pollution.

Carbon Monoxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, that is produced from both natural and manmade processes.

Agricultural activities: ammonia is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere. Use of insecticides, pesticides and fertilizers in agricultural activities has grown quite a lot. They emit harmful chemicals into the air and can also cause water pollution.

Exhaust from factories and industries: manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air. Manufacturing industries can be found at every corner of the earth and there is no area that has not been affected by it. Petroleum refineries also release hydrocarbons and various other chemicals that pollute the air and cause land pollution.

Mining operations: mining is a process wherein minerals below the earth are extracted using large equipment. During the process dust and chemicals are released in the air causing massive air pollution. This is one of the reason which is responsible for the deteriorating health conditions of workers and nearby residents.

Indoor air pollution: household cleaning products, painting supplies emit toxic chemicals in the air and cause air pollution

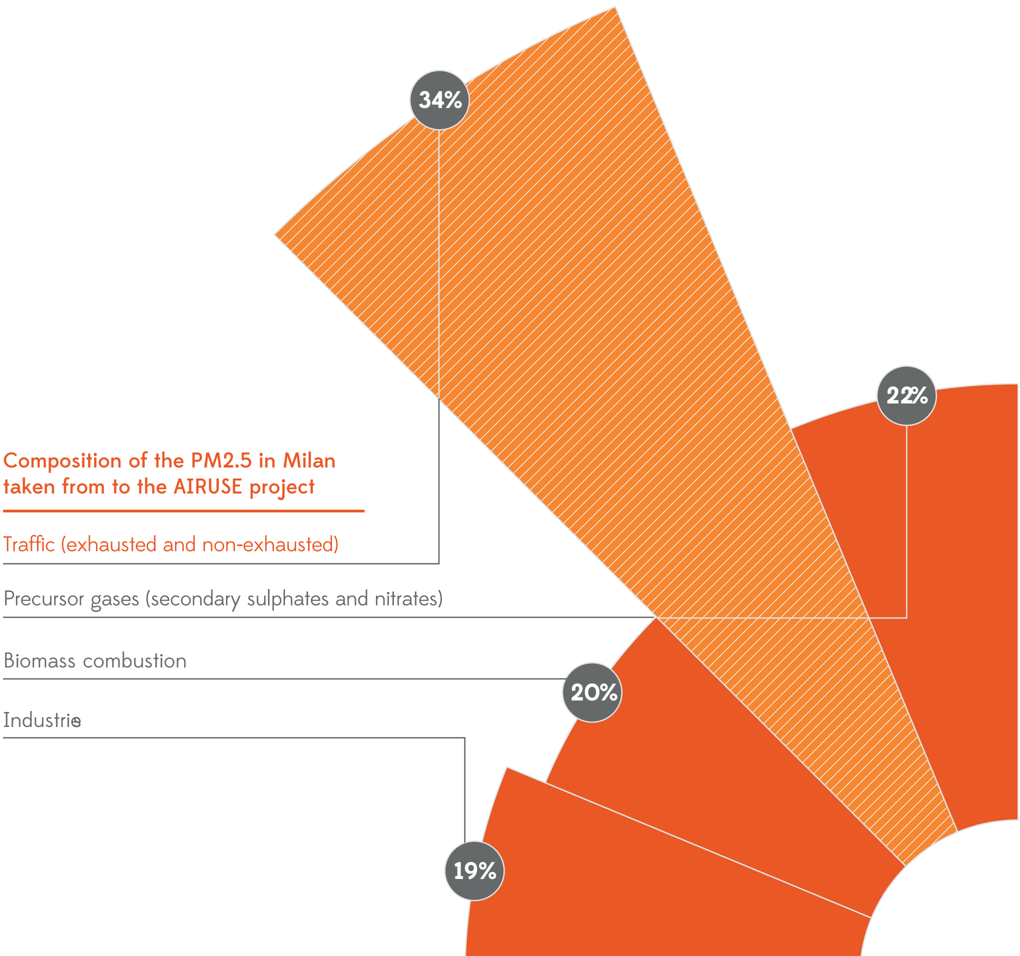


Chart 1.5: Composition of PM 2.5

The heavy cost of air pollution

The development of policy for reducing the risks of air pollution is informed through the quantification and monetization of effects. Quantification highlights both the magnitude and the variety of impacts.
The monetization process typically accounts for healthcare costs, lost productivity, and 'welfare' or 'utility', placing a value on good health per se. Monetization permits the costs of action to reduce pollutant exposure to be compared with the benefits, to ensure that there is a sound economic basis for action.

According to the World Health Organization, outdoor air pollution is responsible for the premature death of over 3 million people worldwide each year, over 3 million years of life lost each year.
These values, however, grow considerably, up to 7 million v, including the effects of indoor pollution.
About 90% of the world population lives in places where air quality levels do not meet the limits set by the WHO.
The European Environment Agency estimates that in 2014 exposure to high concentrations of NO2, O3 and PM2.5 in Europe was responsible for the premature death of over 500,000 European citizens. If we want to make a comparison, on average in Europe the number of victims caused by air pollution is about 20 times that of victims of road accidents.

The effects of air pollution on health, crop and forest yields, ecosystems, the climate and the built environment also entail considerable market and non-market costs. The market costs of air pollution include reduced labour productivity, additional health expenditure, and crop and forest yield losses.
The Organisation for Economic Co-operation and Development (OECD) projects that these costs will increase to reach about 5% of European gross domestic product (GDP) in 2060 (OECD, 2016), leading to a reduction in capital accumulation and a slowdown in economic growth.
Non-market costs are those associated with increased mortality and morbidity (illness causing, for example, pain and suffering), degradation of air and water quality and consequently the health of ecosystems, as well as climate change.
In 2015, more than 80 % of the total costs (market and non-market) of outdoor air pollution in Europe were related to mortality, while market costs were less than 10 %. OECD estimates that the total costs amount to EUR 1 100 per capita for 2015 and around EUR 2 480 to 2 540 per capita for 2060, corresponding to about 5 % of income in both 2015 and 2060.
The non-market costs of outdoor air pollution amount to USD 1 200 (around EUR 1 030) per capita in 2015 and are projected to increase to USD 2 610-2 680 (around EUR 2 250-2 310) in 2060 in the OECD region.

USED COST-BENEFIT ANALYSIS

The European Commission has in the development of policy on air pollution since the mid-1990s. Results from the latest analysis are shown in Table N. 1.5 as economic assessment, including results for the European Union as a whole.

According to the European Commission, the costs related to the health impacts of air pollution in 2010 were between 330 and 940 billion euros: these are values ranging from just under 2% to 6% of European GDP

The economic assessment considers several dimensions of value: healthcare costs, lost productivity, pain and suffering, and aversion to risk. It is notable that the economic analysis indicates that the most-studied morbidity endpoint from the epidemiology literature, hospital admissions, represents only a small part of the overall morbidity impact.

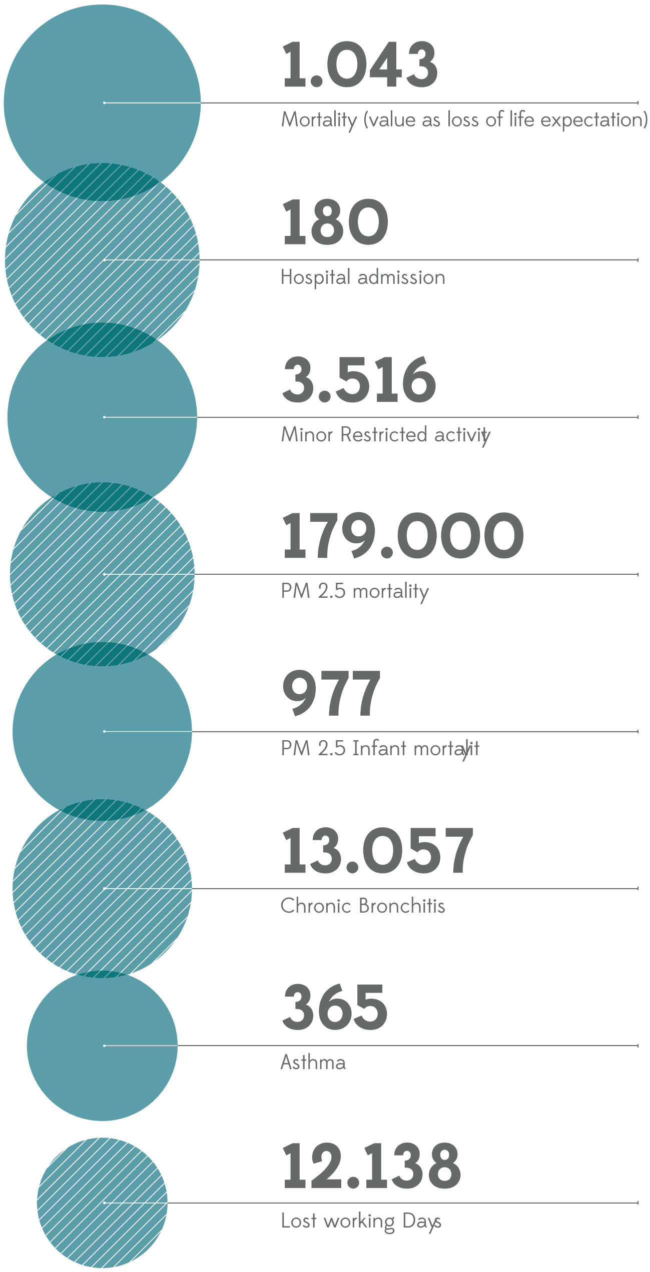


Chart 1.6: Cost Benefit Analysis

Number of death

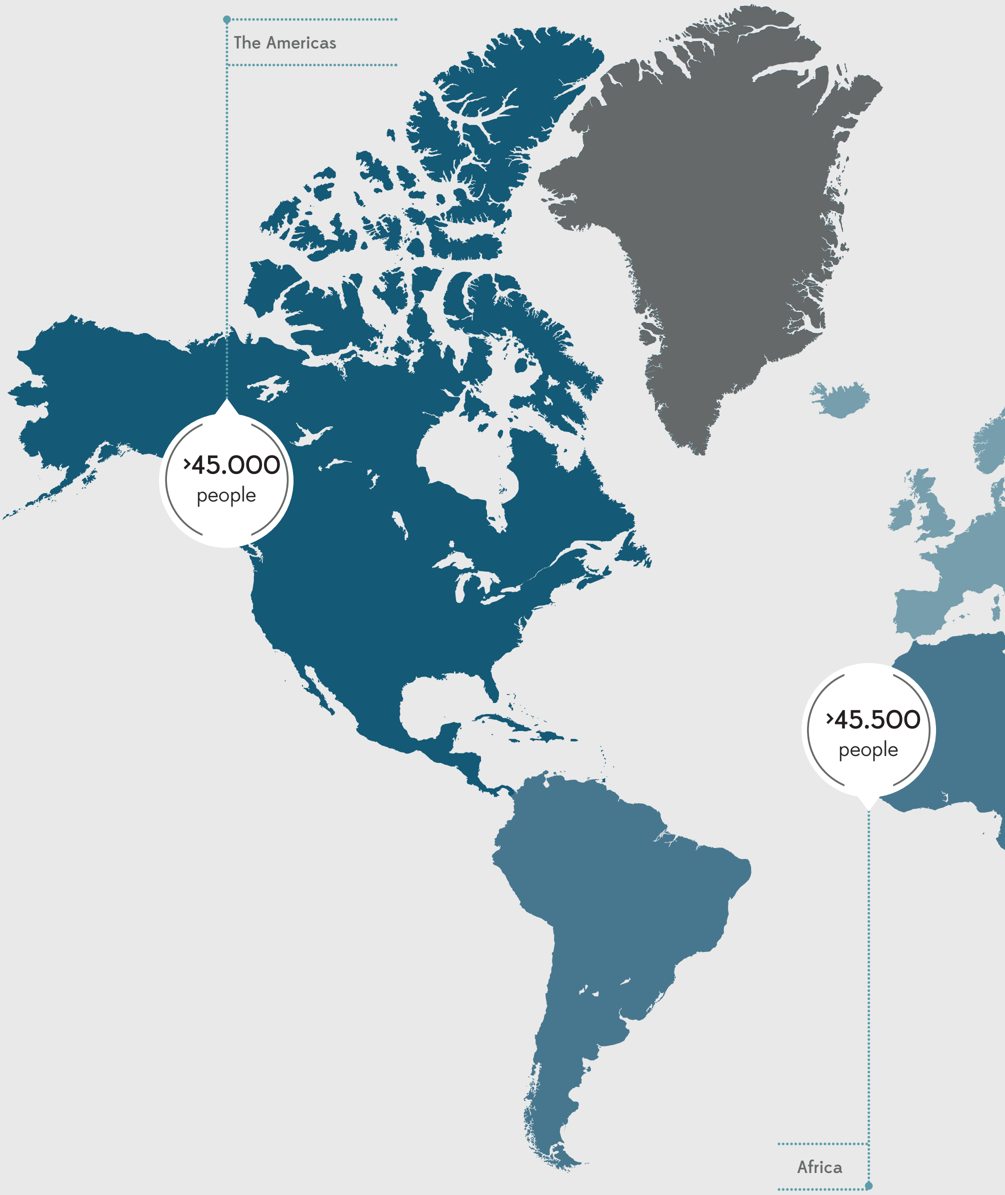
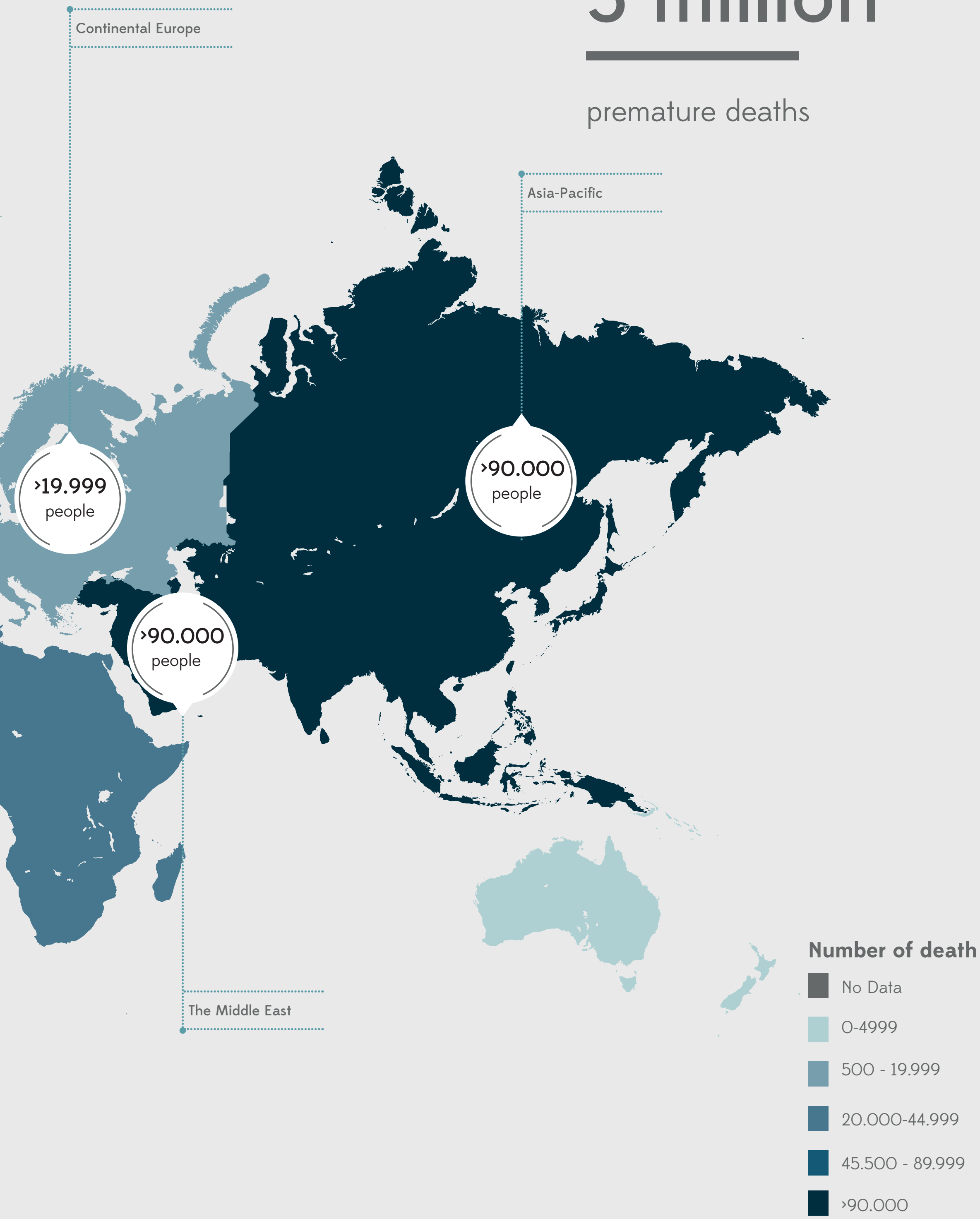


Chart 1.7: Number of Death people

3 million

premature deaths



Air Quality Standard

The EU has been working for decades to improve air quality by controlling emissions of harmful substances into the atmosphere, improving fuel quality, and integrating environmental protection requirements into the transport, industrial and energy sectors.
The chart n. 1.8 illustrates the framework of the EU's clean air policy, based on three main pillars:
1. Ambient air quality standards set out in the Ambient Air Quality Directives, requiring the Member States to adopt and implement air quality plans and meet standards in order to protect human
health and the environment;
2. National emission reduction targets established in the National Emission Ceilings (NEC) Directive (EU, 2016), requiring Member States to develop National Air Pollution Control Programmes by 2019 in order to comply with their emission reduction commitments;
3. Emission and energy efficiency standards for key sources of air pollution, from vehicle emissions to products and industry. These standards are set out in EU legislation targeting industrial emissions, emissions from power plants, vehicles and transport fuels, as well as the energy performance of products and non-road mobile machinery.

The Italian legislation, for the first time with the D.P.C.M. 28/3/1983, air quality limit values have been adopted, or limits for the concentration of air pollutants in the environment to be respected throughout the national territory (defined as: levels set on the basis of scientific knowledge in order to to avoid, prevent or reduce the harmful effects on human health or the environment in human health or the environment as a whole - Legislative Decree 4/8/99, No. 351).

Italy does not yet have an organic and specific regulation for the control of air quality in closed living environments; however, following an agreement between the Ministero della Salute, the Regions and the Autonomous Provinces, guidelines have been issued for the protection and promotion of health in confined spaces.
The guidelines provide fundamental information for the evaluation and management, in terms of public health, of the health risks associated with indoor air pollution as well as technical indications to guide the prevention and control of these risks.
On the legislative level an important intervention for the reduction of indoor pollution from tobacco smoke is given by the Decreto del Presidente del Consiglio dei Ministri of 23 December 2011 on the protection of health of non-smokers and establishes the technical requirements of smoking rooms, the relative ventilation and air-exchange systems and the models of the signs related to the prohibition of smoking.
The decree aims to establish a unitary regulatory framework for the assessment and management of air quality. The purpose of the decree is to aim at improving or maintaining ambient air conditions. The principles on which it is based are based on the intention to aim for high and homogeneous quality standards, to guarantee timeliness of information between institutions and to the public and to base any assessment on the data obtained from the measurement networks; composed of fixed sites, representative for each area and other techniques that follow the canons of efficiency, effectiveness and economy.
This decree revises the limits for pollutants already regulated and new ones are introduced, such as for the finest particulate matter, PM2.5 (indicated in Directive 2008/50 / EC), for heavy metals and for polycyclic aromatic hydrocarbons (from directive 2004/107 / CE). There are strict definitions for each pollutant, interesting are those of the particulate components

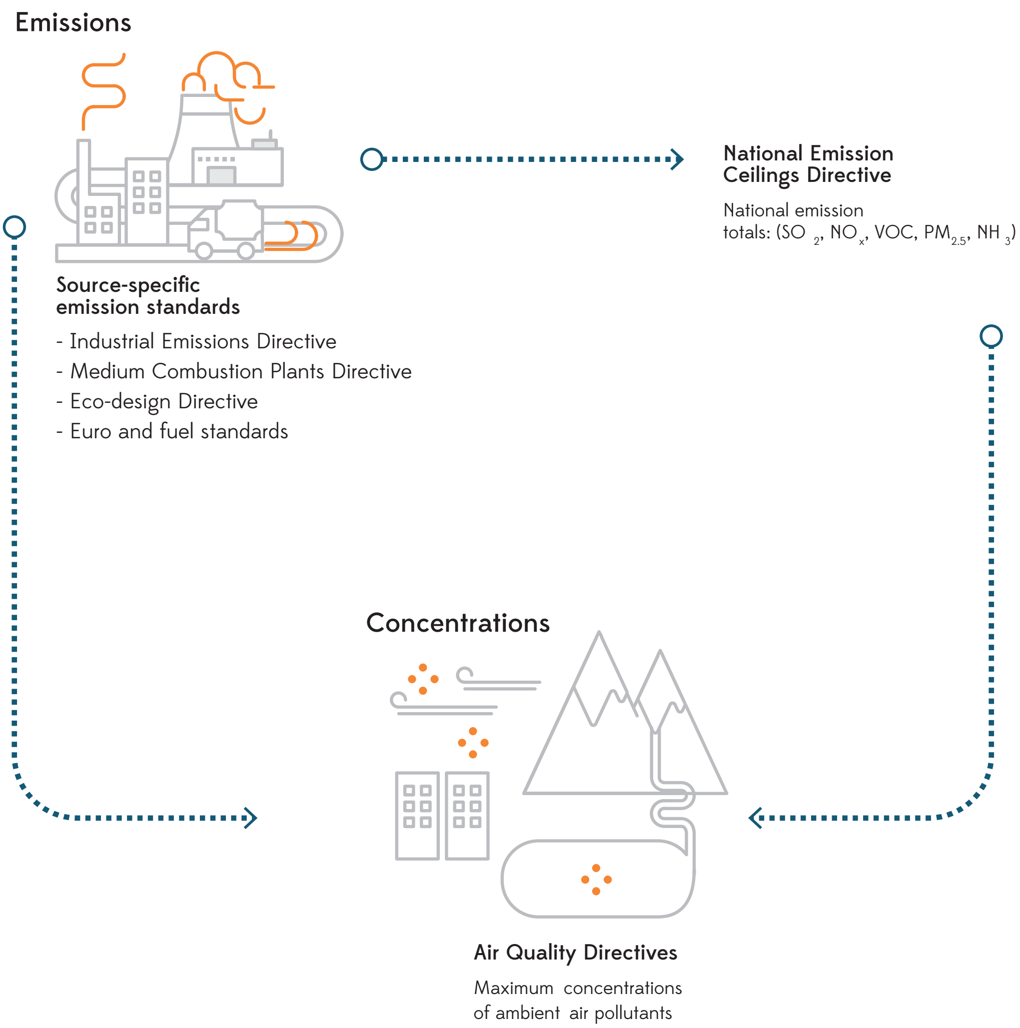


Chart 1.8: EU clean air policy – the policy framework

How climate change affects the air

Population growth, urbanization, developments in the way that we travel, our pursuit and use of energy, new approaches to producing and sourcing food, and many other transitions have all delivered benefits for individuals and society. Yet, in combination, such changes have often created unintended new and complicated threats to health and wellbeing. Human beings are now using natural resources at an unprecedented rate and are damaging global systems and processes, on which we all rely for health and wellbeing.

Many of the global environmental changes – from depletion of the ozone layer, to ocean acidification, to climate change – can be linked to pollution of the atmosphere by human activity. This emphasizes both the fragility and the interconnectivity of global systems and processes.

The pollutants primarily responsible for climate change often share common sources with the toxic pollutants that damage health in our towns and cities. When we burn fossil fuels in vehicles, in our homes or in industry, health-damaging chemicals (notably SO_2, oxides of nitrogen including NO_2, and PM) are released. At the same time, fossil fuel combustion produces gases such as CO_2 and NO_2, which contribute to warming of the planet. One consequence is that measures to reduce emissions of greenhouse gases through energy efficiency, and most of the options for switching from fossil to other fuels, also reduce local air pollution. Thus, policies and interventions that tackle local air pollution can address climate change, and vice versa. They are said to offer 'co-benefits'. However, there are some policy options that generate 'trade-offs'. For example reducing reliance on fossil fuels by increased burning of biomass (typically biological material derived from recently living plants) may increase particle emissions. Similarly, 'end-of-pipe' options for cleaning flue gases reduce overall energy efficiency and increase the pollutants that they do not specifically target, potentially contributing to both climate change and local air quality problems.

Some policy options introduce unexpected complications and can have unanticipated negative consequences. For example, the shift away from petrol and towards diesel for the small engines that power our cars has reduced tailpipe CO_2 emissions. However, critically, the shift to diesel has also contributed to levels of health-damaging airborne particulates in the air of our towns and cities. Notably, too, the Air Quality Expert Group in its 2007 report Air quality and climate change: a UK perspective[4] observed that, while the situation is complicated, the perceived climate benefits of reduced CO_2 in tailpipe emissions are, to an extent, offset by increased refinery emissions of CO_2 due to increased demand for diesel, and the climate-warming effects of black carbon particles that diesel engines emit. Fig 22 provides a simple illustration of how climate change and air pollution policies can interact.

By 2013, the concentration of CO_2 in the atmosphere had increased by around 42%over the levels present before the Industrial Revolution. In 2013, the Intergovernmental Panel on Climate Change (IPCC) concluded that, unless very stringent emission standards are achieved, by the end of the 21st century global surface temperatures will be more than 1.5°C above their 19th-century levels.[7] Disturbingly, the IPCC expressed medium confidence that a 'business as usual' scenario, in which emissions remain high, carries a 50:50 chance that warming will exceed 4°C by 2100. Such a rise will have huge implications for health, wellbeing and the global community itself.

Even in outline, the interconnections between air quality and climate change present a complex and sometimes confusing picture. However, the headline message for society, supported by an overwhelming scientific consensus, is that climate change is a product of human activity and, especially, emissions from the combustion of fossil fuels. By extension, any consideration of the health effects of human-induced air pollution is incomplete without including the many and diverse health and wellbeing impacts that are already taking place owing to the changing climate.

In a recent report, a working group of the IPCC observed that, through shifts in weather patterns and other consequences, climate change is both a direct and an indirect risk to health.14 Through its impacts on air quality, water and food, it is already affecting lives and livelihoods across the globe. In 2014 the WHO estimated that, between 2030 and 2050, climate change will cause an additional 250,000 deaths worldwide per year from malaria, diarrhoea, heat exposure and undernutrition.

Figure 1.2: How climate change can effect out planet

The Italian challenge

According to the European Environment Agency, Italy is among the first countries in Europe for premature deaths caused by exposure to air pollution with about 91 thousand deaths: 66,630 premature deaths attributable to exposure to PM2.5, 21.040 to NO2 and 3,380 at O3.

With more than 1,500 premature deaths per million inhabitants caused by exposure to air pollution, Italy has decidedly higher values than the European average, equal to about 1,000 premature deaths, and to those of other major European economies:

- about 1,100 premature deaths for Germany,
- about 800 for France and the United Kingdom,
- just over 600 from Spain.

The European Directive National Emission Ceilings (NEC) sets national targets for 2030 to reduce emissions of PM2.5, NOX, SOX, VOC and NH3.

These emission limits are intended to achieve air quality levels that do not have negative impacts and significant risks to human health and the environment.

Member States will have to complete the transposition process by 1 July 2018 and draw up a national program against air pollution by 2019 which will define the measures to be implemented to achieve these targets.

The emission scenarios of reference show that, with the policies currently in force, the targets set by the Directive will not be achieved.

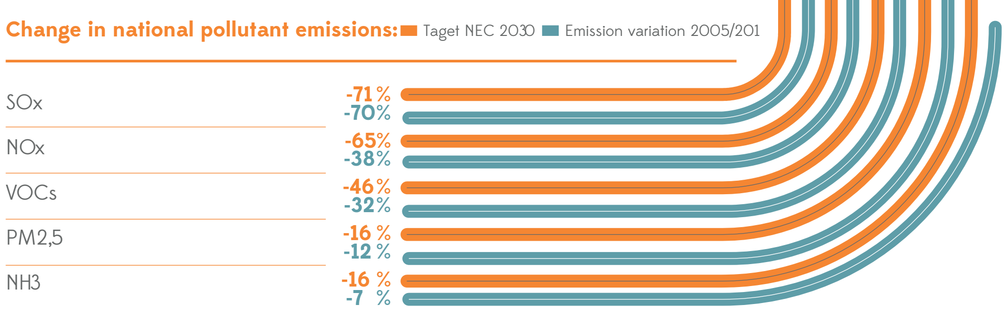


Chart 1.9: Change in national pollutant emissions

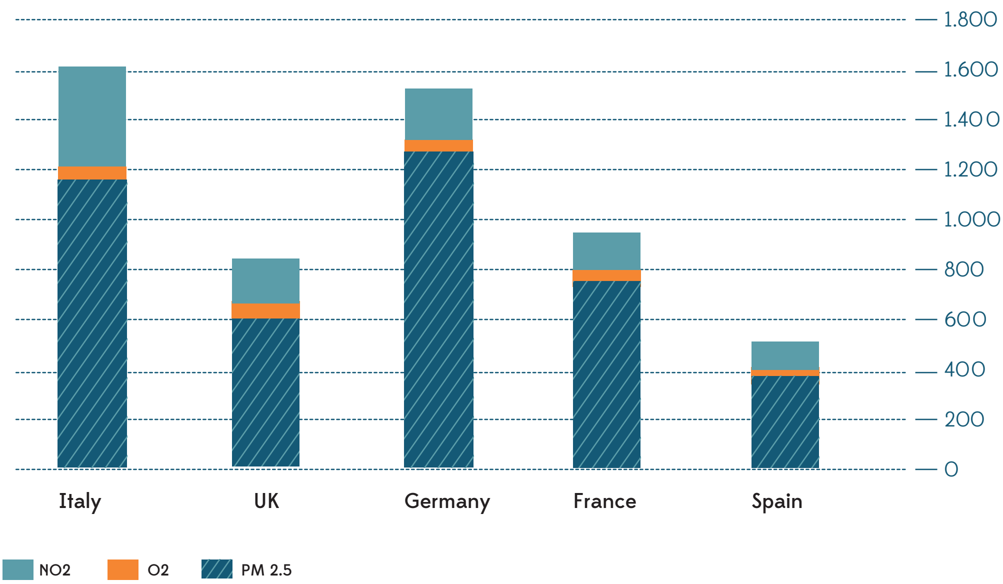


Chart 1.10: Number of premature deaths due to air pollution in some European countries in 2013, total value (left) and per million inhabitant (dx)

Starting from the elaborations carried out with MINNI (National Integrated Model supporting International Negotiation on Air Pollution issues), it was possible to reconstruct the distribution of exposure to air pollution. What emerges is a picture dominated by a vast area of criticality represented by the pianura Padana, which is affected by particularly unfavorable meteorological and orographic characteristics. To this are added a few other localized areas - associated with urbanization, presence of industrial activity, environmental conditions - which affect the province of Florence and Perugia, the metropolitan areas of

The European Commission has activated a series of infringement procedures against 19 of the 28 Member States.

In February 2019 the European Commission launched the second phase of the infringement procedure against Italy (12 zones) and 4 other countries - Germany (28 zones), France (19 zones), Spain and Great Britain (16 zones) - for exceeding the NO2 limits.

How China React To Air Pollution

China has faced a fast development of the industrial sector that brought this country to become the leader of production of goods in the world so that is considered the factory of other countries. For almost 20 years china developed its industry thinking more to increasing of the wellness of population without thinking too much to the sustainability side and using as much as possible the environment. Nevertheless China's air pollution has by now reached an extremely critical state and the government started to take in account the environment considering it as a value and not only as a resource. For instance air pollutants like ozone, PM2.5 and acid rain, are growing more serious and frequent to form regional compound air pollution. Simultaneous large-scale severe air pollution episodes in many regions have been rising. This significantly put a constraint on the sustainable development of Chinese society and economy, in the same time it threaten public health. The regional air pollution is giving huge challenges to the environmental management system. For sure is very difficult or may be impossible to stop the growing of air pollution just through traditional management.

Air quality management efforts (for instance the Beijing Olympics, the Shanghai Expo and the Guangzhou Asia Games) has proved how the collaboration of regional air pollution prevention and control are effective approach in improving air quality internationally and in regional air quality management. It is necessary to explore and establish new regional air pollution prevention and control management system, which requires an integrated system planning across the whole country. Today China is hardly working in order to prevent the production of a huge amount of pollutants in future, in order to do so, On December 5, 2012, Ministry of Environmental Protection, National Development and Reform Commission, and the Ministry of Finance jointly issued "12th Five-Year Plan on Air Pollution Prevention and Control in Key Regions". And the plan has being approved by the China's State Council earlier. "The 12th Five-Year period will see rap-id industrialization and urbanization across China. The consumption of resources and energy will continue to rise and air quality will be threatened by air pollution. Clean use of energy and clean energy production will be advanced. Multiple pollutants control measures will be implemented and emissions will be reduced. A total of 19 provinces, autonomous regions and municipalities are involved, covering a combined area of approximately 1,325,600 square kilometers or 13.81% of the nation's land area. The plan encompasses the regions of Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, as well as the city clusters of Central Liaoning, Shandong Province, Wuhan region, Changsha-Zhuzhou-Xiangtan, Chengdu-Chongqing, Straits Fujian, Central and Northern Shanxi, Shaanxi Guanzhong, Gansu-Ningxia, and the city of Urumqi in Xinjiang." (Lijian, 2013)

Air Pollution is a big problem especially in china, and every government is struggling to understand the right problems to tackle the pollution; moreover china is a huge country with one of the biggest population in the world. It's crucial before to start to fight pollution understand with are the weaknesses of Chinese organization in order to find the right opportunities to work in.

In the study: "12th Five-Year Plan on Air Pollution Prevention and Control in Key Regions" 4 key areas are identified:

-Obsolete Air Environmental Management: The current environment management model is hardly appropriate for the air pollution prevention and control requirements. Regional air environment is-sues require the establishment of an integrated, unified planning mechanism between the local regions. According to the current management system and

regulations, the local government is responsible for the local environment quality, carrying out the measures aimed at improving local environment quality and working separately, making it hard to solve regional air quality issues.
-Relatively Simple Elements to Pollution Control: For a long time, China has not established a comprehensive multi-pollutant con-rol system aimed at improving air quality. From the perspective of pollution control factor, the main focus of the pollution control has been on SO2 and PM from industrial sources. Pollution controls for NOx and VOCs from fugitive dust, non-point sources, automobiles and non-road vehicles sources have been insufficient.
-Weak Environmental Monitoring and Statistical Foundations: Air environment quality monitoring indicator is incomplete, since most of the cities have not set up ozone and PM2.5 monitoring, which leads to weak control for data quality, so that it cannot reflect the current air pollution situation. VOCs and fugitive dust are not included in the environment statistic system, so the lack of data is hard to fulfill environment management requirements.
-Incomplete Regulation Criteria: The current laws and regulations about prevention and control of air pollution lack effective measures to prevent and control air pollution and mobile pollution sources on a regional level. They also lack of VOCs emission standards, comprehensive city dust management systems, and vehicle fuel standards lag behind the motor vehicle emission standards.
Is pretty clear that a single simple solution is not possible. What is realistic to think is a combination of solutions that working together can help to reduce significantly the Air Pollution problem.
In particular a System of different actions and projects regulated with a comprehensive multi-pollutant control system, consistently monitored and studied that works in an environment of new regulations and laws that could help to further develop those.
There are three main topics talking about fighting air pollution: Prevention (policy,regulations, investments, etc...) Control (all those project and actions working inside the city to low down the level of Air Pollution) Monitoring (monitoring the level of pollution constantly).
Every of those three actions are crucial in order to fight Pollution and create a better environment where citizens can continue to live without a constant fear of open air.

How we are living?

The Indoor Generation

Our day-to-day world comprises a range of micro-environments through which we, as individuals, uniquely move, live and breathe through the course of a day – and indeed throughout our lifetime.

Our day-to-day world comprises a range of micro-environments through which we, as individuals, uniquely move, live and breathe through the course of a day – and indeed throughout our lifetime. It includes, of course, the outdoor environment, which is affected by a wide range of factors. Outdoor air, in turn, influences the quality of the air in indoor environments. But indoor environments also have their own sources of contaminants, so that consideration of particular exposures in the home, public places, schools/colleges, hospitals, workplaces and transport is very important in assessing impacts of the breathed environment on our health and wellbeing.

Figure 1.3: Air pollution effect

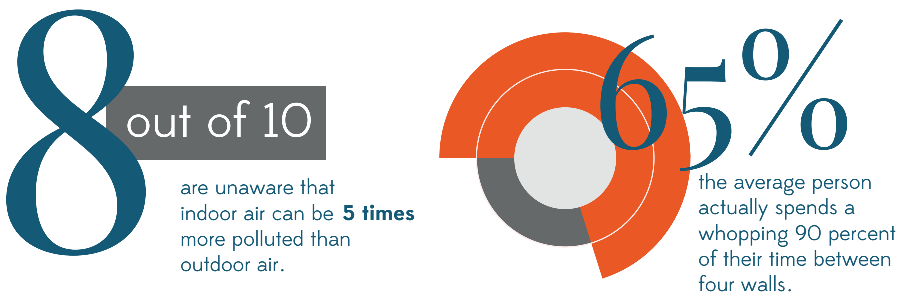
You are probably spending more time indoors than you think. When surveyed, people in key countries across Europe and North America estimated that they spend 66 percent of their time inside. But further studies have shown that the average person actually spends a whopping 90 percent of their time between four walls.
The truth is that most of the people didn't even realize that all that time indoors has a detrimental effect on our health and well-being, similar to poor diet or lack of exercise. They are also unaware that pollution is often worse indoors than outdoors. The poor air quality in our homes, our offices and our schools is associated with costly health problems like asthma, respiratory disease, heart disease and chronic obstructive pulmonary disease. They can be up to 5 times more polluted than the outside.

And if you're spending most of your time indoors, you're probably not getting enough daylight, which leads to lower brain function, sleep quality, mood and productivity.

The phrase "air pollution" brings to mind images of a factory belching smoke into the air or smog clouding a city skyline. But the air inside our homes and buildings can be up to five times more polluted than the air outdoors. According to a YouGov survey, nearly 80 percent of people don't know this.
But how does the air indoors get so bad? The air indoors is basically the same as outside air, with added pollution from all the materials around us. Anything from paint and cleaning products, to furniture and upholstery, to plastic toys and carpets, can trap dust and become a pollutant. Children's bedrooms are often the most polluted rooms .

Do you often cook, burn candles or dry clothes indoors? Each of these adds even more impurities. Moisture leads to mold and mildew, and their fungal spores contaminate the air.
Spending so much time indoors also cuts us off from natural light. As a species, we evolved to need daylight. "From the year 1800 to 2000, we've moved from 90 percent of people working outside to less than 20 percent," says Russell Foster, the head of the Nuffield Laboratory of Ophthalmology and the Sleep and Circadian

Chart 1.11: National Percentage time spent

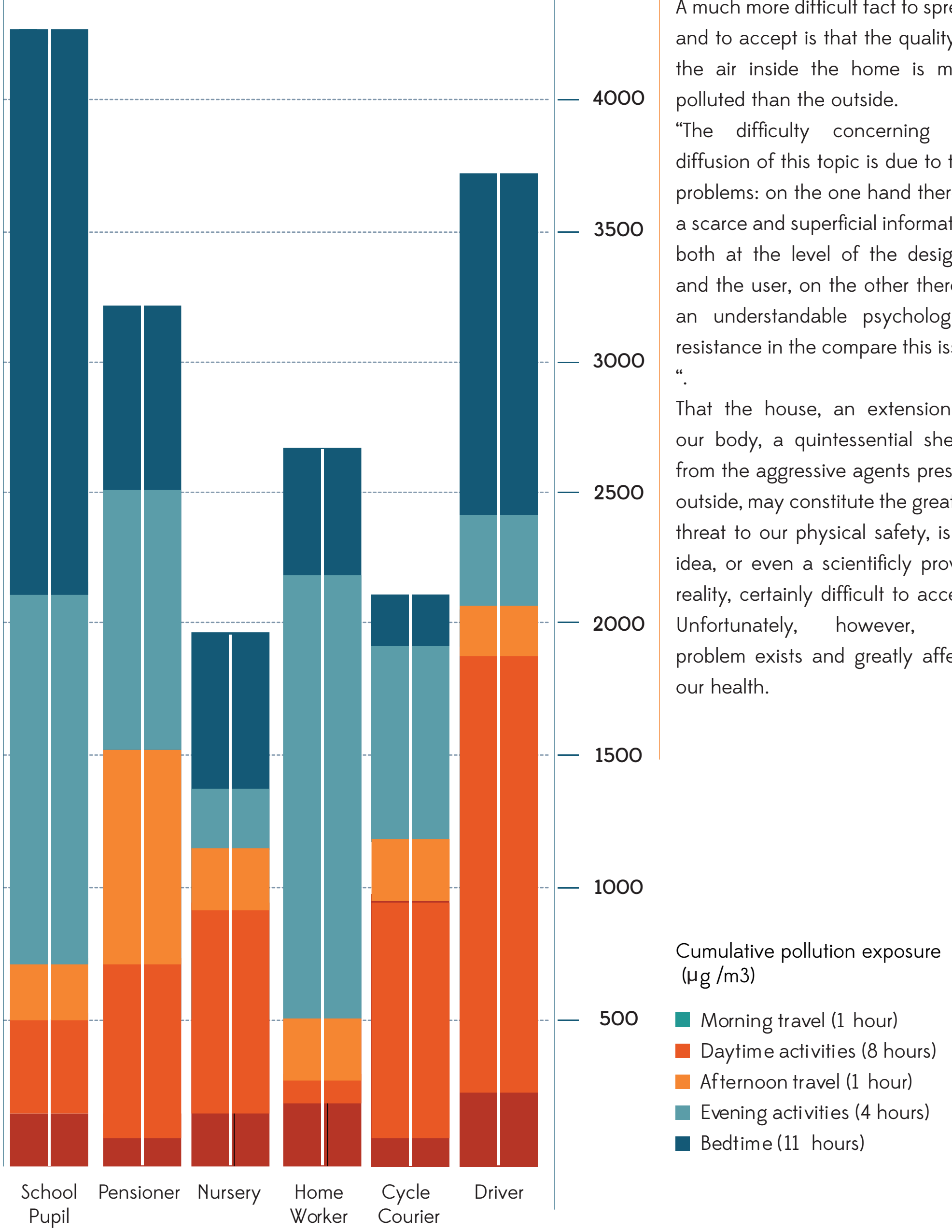


Indoor Air

The quality of the air indoors is important, because it is here that we spend the majority of our time-whether that is at home, at work, at school, in shops or in vehicles. One important source of indoor air pollution is outdoor air, gaining ingress through windows, doors and general building 'leakiness'. So,'clean' outdoor air will help to ensure high-quality air indoors. But there are many important and sometimes potent sources of pollution that are located inside buildings and other internal spaces. These include both natural and anthropogenic sources.

But what is meant when we talk about "Indoor Pollution"?
The Ministero della Salute defines it as "the presence in the air of environments confined with physical, chemical and biological contaminants not naturally present in the outdoor air of high quality ecological systems".
Specifically, the expression "indoor environment" refers to delimited, circumscribed environments or, as is often claimed, non-industrial life and work (for the latter, by the way, specific restrictive legislation applies); and in particular, to those used for dwelling, leisure, work and transport. Consequently the term "indoor environment" includes, in fact, houses, public and private offices, community structures (hospitals, schools, barracks, hotels, banks, ..), premises for recreational and social activities (cinema , bars, restaurants, shops, sports facilities, ..) and finally public and private means of transport (car, train, plane, ship)
This risk is not limited to categories selected for age and health status, as in the case of occupational exposure, but it affects almost the entire population, which includes, as we know, more susceptible groups such as children, the elderly and people already suffering from chronic diseases (heart, respiratory, bronchial asthma, allergies and the like).
In short, the risks that threaten human health can derive from two causes: the concentration of pollutants and the duration of exposure, ie concentration in relation to time ..). If we consider, as the EPA reminds us and warns us, that "the concentrations of pollution in domestic environments are one to five times greater than those of the outside and that indoor exposure is ten to fifty times higher than exposure outdoor "we can begin to understand how indoor air is a problematic issue to consider seriously.

Chart 1.12: How a person's daily exposure to pollution



A much more difficult fact to spread and to accept is that the quality of the air inside the home is more polluted than the outside.
"The difficulty concerning the diffusion of this topic is due to two problems: on the one hand there is a scarce and superficial information both at the level of the designer and the user, on the other there is an understandable psychological resistance in the compare this issue ".
That the house, an extension of our body, a quintessential shelter from the aggressive agents present outside, may constitute the greatest threat to our physical safety, is an idea, or even a scientificly proven reality, certainly difficult to accept. Unfortunately, however, the problem exists and greatly affects our health.

Workplace Air

Workplaces constitute a unique form of environment where exposures to harmful inhaled agents may occur; they may be predominantly indoor (typical factory settings, offices, salons and commercial environments), outdoor (including agricultural- and environmental-based jobs), underground(including mining and hyperbaric tunnelling) or in hostile environments (including offshore, altitude and deep-sea work). Health risks arising from air pollutants in the workplace can be appreciably higher than those of the same pollutants occurring in the domestic situation, as exposure concentrations can be substantially higher.

It is clear that outdoor air quality issues still apply to many workers, particularly those who work near sources of outdoor air pollution including, for example, urban-based traffic police and street cleaners. Also, some workplaces can be local 'hotspots' of air pollution, giving rise to increased exposure and possible elevated risk of respiratory conditions among neighbourhood inhabitants.

Workers in these diverse types of workplace may find it difficult to reduce or materially influence their exposure to harmful inhaled agents. Because of the reliance on the employer to control the nature of the air breathed by workers, workplace air quality is normally regulated, although the nature and type of the regulation will vary from country to country. In the UK, the Health and Safety at Work Act and subsequent Control of Substances Hazardous to Health (COSHH) regulations contain much of the legislation used to control harmful inhaled exposures at work. These underpin a risk-based approach, where those responsible for the quality of air in workplaces assess likely exposure, estimate the likely risk, and develop a set of interventions in the so-called 'hierarchy of control' to reduce the risks to health.

The lung is vulnerable to exposure to a broad range of harmful substances in the workplace, including allergens, asthmagens, organic dusts, mineral dusts and fibres, solvents and VOCs, gases and chemical carcinogens. Newer types of exposure include engineered hypoxic environments to control ignition risks. This serves to illustrate how complex workplace air quality considerations can be, and shows that these considerations need to evolve with changes in workplace design.

In addition to the more traditional work-related respiratory diseases, perhaps more difficult to quantify are illnesses that arise from a particular workplace environment where a single, particular responsible exposure has not yet been identified. These include building-related illness (otherwise known as 'sick building syndrome') – a constellation of non-specific upper airway, eye and nasal symptoms often associated with newer building occupancy and also with perceived lack of control by the occupants over their environment. The roles of various exposures, including VOCs, O3 and PM, have been assessed, and work continues to identify the best preventative strategies. Other issues relevant to workplaces/offices include the use of large numbers of printers and photocopiers that may emit O3. More generally, poor air quality is known to have measurable impacts on worker productivity.

It is also important to recognise that certain workplaces are public areas, and here air quality will influence, and be influenced by, both public and worker occupancy. While exposure to environmental tobacco smoke may be less of a risk nowadays given recent UK-based legislation, the use of cleaning and personal care products, sprays and vaporisers, and also emissions from large quantities of stored items and products (eg inside shops and warehouses), may pose particular air quality issues.

> **“Work in a polluted environment reduces the employee’s capabilities”**

Figure 1.4: Indoor Workplace Air

Air quality at school

Since children spend a large part of their time at school, indoor air quality in schools has received particular attention in recent years. The internal air within schools is often of poor quality. Schools are often poorly ventilated, and several pollutants have been found in classrooms.

A study assesses the effects of Indoor Air Quality (IAQ) on respiratory health of schoolchildren living in Norway (Oslo), Sweden (Uppsala), Denmark (Arhus), France (Reims) and Italy (Siena and Udine). In most centres, the indoor mean concentration of PM10 exceeded the 50 μg·m3 cut-off suggested for long-term exposure. Elevated mean concentrations were mainly in Danish and Italian schools. A level greater than 50 μg·m−3 was found in 77.8% of the classrooms, and a level greater than 150 μg·m−3 (standard for 24-h exposure) was found in Italy and Denmark.

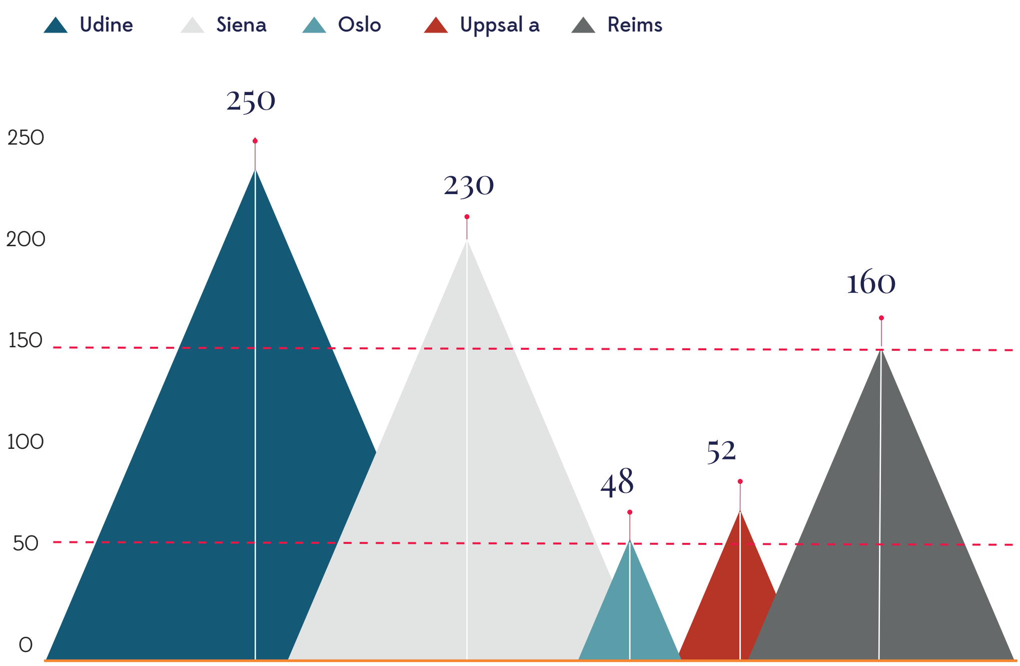
Mean concentrations of CO2 exceeded 1000 ppm (standard for good IAQ) in all schools, except for Sweden, and in 66% of the classrooms (chart n. 1.13). The highest values were measured in Italy, followed by France and Denmark.

Pupils exposed to an elevated level of indoor PM10 and CO2 showed higher prevalence of all disorders than those exposed to a low level, significantly so for dry cough at night, and, as regards CO2, also for rhinitis.

In addition, about 34% of the children were exposed to tobacco smoking at home, ranging from 17.4% in Sweden to 48.4% in France. All disorders were more frequent in exposed than unexposed children, significantly so for wheeze and dry cough.

In conclusion, this study shows levels of CO2 and PM10 exceeding the suggested air quality standards in a large number of European classrooms. Exposure to elevated levels affects the respiratory health of schoolchildren. Such results foster the advocacy for improving school environments, initially by providing adequate ventilation.

Chart 1.13: Indoor particulate matter with a 50% cut-off aerodynamic diameter of PM 10



The line a 50 shows the US environmental Protection Agency (EPA) annual standard. The line at 150 shoes the US EPA 24-h standard

The air we breathe

One important source for indoor air is outdoor air, gaining ingress through windows, doors and general building 'leakiness'. So,'clean' outdoor air will help to ensure high-quality air indoors. But there are many important and sometimes potent sources of pollution that are located inside buildings and other spaces.

The quality of the air indoors is important, because it is here that we spend the majority of our time –whether that is at home, at work, at school, in shops or in vehicles. One important source for indoor air is outdoor air, gaining ingress through windows, doors and general building 'leakiness'. So,'clean' outdoor air will help to ensure high-quality air indoors. But there are many important and sometimes potent sources of pollution that are located inside buildings and other internal spaces. These include both natural and anthropogenic sources. More than 900 different compounds are present in indoor air.

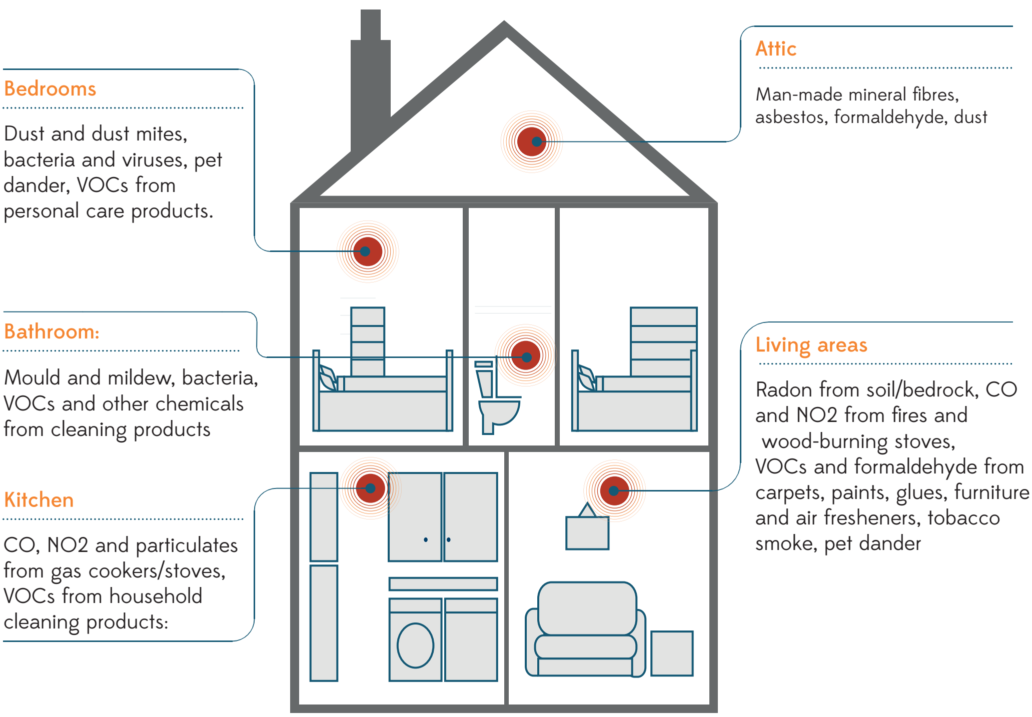
Natural pollution sources include a number of biological ones. We ourselves release pollutants including a personal particle cloud through normal metabolic processes, and also through use of personal care products. In addition, we often share our indoor environment – both deliberately and unwittingly – with various other living organisms. There are pets of course, dogs, cats and sometimes birds, rabbits and rodents, but also various insects and arachnids that enjoy home comforts, especially including house-dust mites, bacteria and moulds that thrive in warm, moist environments. In addition, cut flowers and potted plants may release pollen into the indoor air.

There are a large number of potential 'man-made' pollution sources in indoor environments, especially the home . Probably top of the list in terms of health consequences is the smoking of cigarettes, cigars, pipes etc, giving rise to so-called 'second-hand smoke' containing many noxious substances. In addition, hookahs/shisha smoking, candles, joss sticks and other materials that we burn for recreational purposes emit pollutants into the indoor air.

Combustion appliances – cookers, boilers, open fires and portable gas/paraffin heaters (with no flue) – are particularly significant in terms of total emissions. The building itself, the materials from which it is built and those with which it is decorated are also important potential sources of chemical pollutants – these include the construction materials, as well as paints, glues, furniture, wallpaper and drapery. Cleaning and DIY products, air fresheners and other consumer products such as insecticide sprays that we use in the home are also important.

According to the European INDEX project the most significant of these pollutants (excluding tobacco smoke) in terms of health impact are Volatile Organic Compounds (VOC), Carbon dioxide (CO2), Carbon monoxide (CO), Particulate Matter PM

Figure 1.5: Distribution of air pollution in a home



Air Quality Index, AQI

AQI, or Air Quality Index, is a system for translating sometimes confusing or unintuitive pollutant concentration measurements, into one easy-to-understand scale to clearly represent the health risk posed by ambient air pollution. The index formula usually considers up to 6 main pollutants (PM2.5, PM10, carbon monoxide, sulfur dioxide, nitrogen dioxide and ground level ozone), and calculates the respective health risk (or AQI number) for each one at any given time. The overall AQI number at a given moment is dictated by the "riskiest" pollutant, with the highest AQI number.

The index ranges from 0 to 500, where high index values indicate higher levels of air pollution and higher potential for adverse health effects. Any value larger than 300, for example, is considered to be hazardous, while an AQI value of 0-50, on the other hand, represents good air quality.

AQI is computed in different ways around the world. China and America have the two most widely used systems. Both are calculated weighting the six key pollutants. The results of these two functions differ only in AQI scores of 200 and below.

Since the American index system yields higher scores for AQI's under 200, it is thought to be more strenuous. For this reason, the American index has become the general world standard.

0-50

"Good"

Air quality is satisfactory and poses little or no health risk. Ventilating your home is recommended.

Recommendations

Enjoy your usual outdoor activities. It is recommended open your windows and ventilating your home to bring in fresh, oxygen-rich air.

51-100

"Moderate"

Air quality is acceptable and poses little health risk. Sensitive groups may experience mild adverse effects and should limit prolonged outdoor exposure.

Recommendations

Enjoy your usual outdoor activities. It is recommended open your windows and ventilating your home to bring in fresh, oxygen-rich air.

101-150

"Unhealthy for Sensitive Groups"

Air quality poses increased likelihood of respiratory symptoms in sensitive individuals while the general public might only feel slight irritation. Both groups should reduce their outdoor activity.

Recommendations

The general public should greatly reduce outdoor exertion. Sensitive groups should avoid all outdoor activity. Everyone should take care to wear a pollution mask. Ventilation is discouraged. Air purifiers should be turned on.

151-200

"Unhealthy"

Air quality is deemed unhealthy and may cause increased aggravation of the heart and lungs. Sensitive groups are at high risk to experience adverse health effects of air pollution.

Recommendations

Outdoor exertion, particularly for sensitive groups, should be limited. Everyone should take care to wear a pollution mask. Ventilation is not recommended. Air purifiers should be turned on if indoor air quality is unhealthy.

201-300

"Very Unhealthy"

Air quality is deemed unhealthy and may cause increased aggravation of the heart and lungs. Sensitive groups are at high risk to experience adverse health effects of air pollution.

Recommendations

The general public should greatly reduce outdoor exertion. Sensitive groups should avoid all outdoor activity. Everyone should take care to wear a pollution mask. Ventilation is discouraged. Air purifiers should be turned on.

301-500

"Hazardous"

Air quality is deemed toxic and poses serious risk to the heart and lungs. Everyone should avoid all outdoor exertion.

Recommendations

The general public should avoid outdoor exertion. Everyone should take care to wear a quality pollution mask. Ventilation is discouraged. Homes should be sealed and air purifiers turned on.

Carbon Dioxide, CO_2

A colorless, odorless gas at room temperature, carbon dioxide (CO_2) is an abundant substance. It can be a liquid or a solid known as dry ice. Normal cell function produces carbon dioxide. When humans breathe out, carbon dioxide is expelled. Dying plants and burning fossil fuels produce carbon dioxide. All houses have a presence of carbon dioxide, with certain causes creating high levels.

The amount of carbon dioxide in a building is usually related to how much fresh air is being brought into that building. In general, the higher the CO_2 level in the building, the lower the amount of fresh air exchange.

Carbon dioxide builds up in a house, whether from the gas being drawn up from the soil or from the activities of humans and pets. Unless the indoor air is circulated on a regular basis, high levels of carbon dioxide will appear. Levels tend to be higher in the areas of the house where the occupants and pets spend most of their time. Also certain appliances in a house can cause elevated levels of carbon dioxide. These include space heaters, dryers, stoves and any other unvented gas appliance.

IMPACT OF CO_2 ON HUMAN HEALTH.

Carbon dioxide emissions impact human health by displacing oxygen in the atmosphere. Breathing becomes more difficult as carbon dioxide levels rise. In closed areas, high levels of carbon dioxide can lead to health complaints such as headaches and loss of consciousness. Carbon dioxide levels may indicate high levels of other harmful air pollutants such as volatile organic compounds which contribute to indoor air pollution.

Carbon monoxide, CO

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas that is slightly less dense than air. Carbon monoxide consists of one carbon atom and one oxygen atom , connected by a triple bond that consists of two covalent bonds as well as one dative covalent bond.

Carbon monoxide is produced from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce carbon dioxide (CO_2), such as when operating a stove or an internal combustion engine in an enclosed space. Carbon monoxide is also formed as a pollutant when hydrocarbon fuels (natural gas, petrol, diesel) are burned.

Carbon monoxide is a temporary atmospheric pollutant in some urban areas, chiefly from the exhaust of internal combustion engines, but also from incomplete combustion of various other fuels.In closed environments, the concentration of carbon monoxide can easily rise to lethal levels. Indoor carbon monoxide can be produced by: malfunctioning fuel-burning appliances; engine-powered equipment such as portable generators; fireplaces;

CARBON MONOXIDE POISONING

Carbon monoxide poisoning (COP) typically occurs from breathing in too much carbon monoxide. COP is the second leading cause of unintentional poisoning deaths. The most common symptoms are headache, dizziness, nausea/vomiting, confusion, fatigue, chest pain, shortness of breath, and loss of consciousness.

A recent diagnosis about CO toxicity indicate deaths like the first short-term consequence.

The long-term consequences in survivors can range from severe brain damage to a much more common syndrome of less severe but persistent problems. The apparent development of the first neuropsychological symptoms or signs occurring days to weeks after CO poisoning clearly occurs. The most common problems encountered are depressed mood and difficulty with higher intellectual functions (especially short-term memory and concentration)

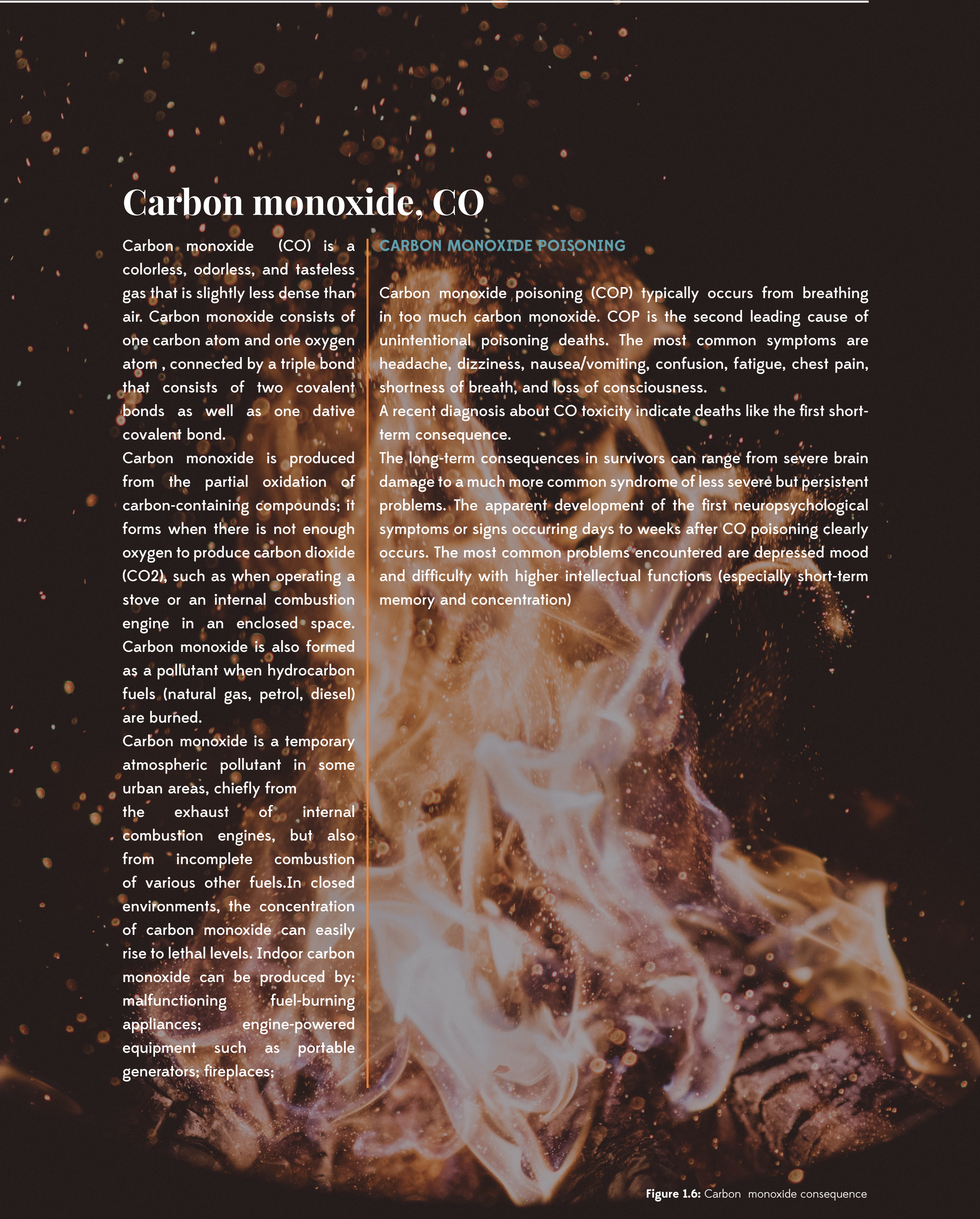


Figure 1.6: Carbon monoxide consequence

Particulate matter, PM2,5

Atmospheric aerosol particles, also known as particulate matter (PM), are microscopic solid or liquid matter suspended in Earth's atmosphere. Particulate matter can be classified according to the size of the particles in: coarse particles, with a diameter between 2.5 and 10 micrometers (PM10); fine particles, with a diameter of 2.5 micrometers or less (PM2.5); ultra-fine particles, with a diameter of 0.1 micrometers or less (UFP). The size, chemical composition, and other physical and biological properties of particles vary with location and time. This variability in pollutant levels derives from differences in pollutant sources. The sources may be natural, such as volcanoes, dust storms, forest and grassland fires, living vegetation and sea spray, or the result of human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes. Ambient PM levels in any location are also affected by local ambient mixtures of gaseous pollutants, meteorology, geography, and seasonal pattern.

The major components of PM include metals, organic compounds including materials of biological origin, inorganic carbonaceous material.

IMPACT OF PM2.5 ON HUMAN HEALTH

The pathogenicity of PM is determined by their size, composition, origin, solubility and their ability to produce reactive oxygen. One group of particulate matter identified, PM2.5, have small diameters, however large surface areas and may therefore be capable of carrying various toxic stuffs, passing through the filtration of nose hair, reaching the end of the respiratory tract with airflow and accumulate there by diffusion, damaging other parts of the body through air exchange in the lungs

PM affects health in two ways: by being toxic or by providing a surface for transporting toxic compounds to where they can do harm. PM can have short-term health impacts over a single day when concentrations are elevated, and long-term impacts from lower-level exposure over the life-course. Effects are amplified in vulnerable groups including young children, the elderly, and those suffering from breathing problems like asthma. The Department of Health and Social Care's independent Committee on the Medical Effects of Air Pollutants (COMEAP) quantified the long-term impacts of UK PM concentrations in terms of mortality as equivalent to 340,000 life years lost.

38% of UK primary PM emissions come from burning wood and coal in domestic open fires and solid fuel stoves9, 12% comes from road transport (e.g. fuel related emissions and tyre and brake wear)10 and a further 13% comes from solvent use and industrial processes.

Volatile organic compounds (VOCs)

Volatile organic compounds (VOCs) are a very large group of organic compounds, which differ widely in their chemical composition but can display similar behavior in the atmosphere. VOCs are emitted to air as combustion products, as vapor arising from petrol, solvents, air fresheners, cleaning products, perfumes and numerous other sources, often when products are used at work or in the home.

VOC emissions can form a significant component of indoor air pollution. A particularly important VOC is formaldehyde, which can be released from furniture, finishes and building materials, such as laminate flooring, kitchen cabinets and wood panels, and is also formed in chemical reactions in the air between other VOCs and chemicals generated from combustion processes, such as smoking, heating, cooking or candle burning. At low concentrations, exposure to formaldehyde can cause irritation to the eyes and upper airways, and is classified as a human carcinogen.
Other sources of VOCs include furnishing, carpets, and upholstery, products for cleaning and polishing, air fresheners, and personal care products, for example fragrance, deodorants, and hair styling products. The aim is to reduce emissions of VOCs against the 2005 baseline by 32% by 2020, increasing to 39% by 2030.

FORMALDEHYDE

Formaldehyde, aldehyde of formic acid, is a colorless gas with an acrid and irritating odor; very soluble in water, reactive in many syntheses, it is the most widespread and best known volatile organic compound (Voc). Formaldehyde is a substance whose potential dangerousness is mainly linked to its extreme volatility and the consequent ease of penetration into our respiratory system. The International Agency for Research on Cancer classifies the chemical formaldehyde as a "certain carcinogen" among the most lethal to humans.
Despite the dangerousness shown, it is found in many products, such as plastics and resins, deodorants, disinfectants, dyes, products for cleaning the body, hygiene products for the home, nail polishes and many others.
Despite the evident evidence of its dangerousness, it is not clear why a series of norms to limit its use and its consequent diffusion is still to be issued.

Figure 1.7: VOCs consequence

Humidity and Temperature

Excessive humidity and inadequate temperatures also affect indoor health. Home humidity levels should not exceed 40-60% and the temperature should never be too high, on average not higher than 20-22 ° C depending on the need. High temperatures and humidity can promote the growth of mold, bacteria and fungi that are harmful to health and are often not visible to the naked eye.

65% of Europeans dry their laundry at home at least once a week and this produces humidity. An average family produces about ten liters per day.

Damp and mouldy environments can increase the risk of developing asthma by 40%, and a European-wide study found that 2.2 million Europeans have asthma as a direct result of living in damp or mouldy buildings. Damp can also provoke allergic reactions. There is only one really effective long-term solution to beating the consequences of a poor indoor climate – to replace the stale air with fresh air. Yet almost 6 out of ten do not air out enough in their homes.

A review of the health effects of relative humidity in indoor environments suggests that relative humidity can affect the incidence of respiratory infections and allergies. Experimental studies on airborne-transmitted infectious bacteria and viruses have shown that the survival or infectivity of these organisms is minimized by exposure to relative humidities between 40 and 60%.

The indoor size of allergenic mite and fungal populations is directly dependent upon the relative humidity. Mite populations are minimized when the relative humidity is below 50% and reach a maximum size at 80% relative humidity. Most species of fungi cannot grow unless the relative humidity exceeds 60%. Relative humidity also affects the rate of off-gassing of formaldehyde from indoor building materials, the rate of formation of acids and salts from sulfur and nitrogen dioxide, and the rate of formation of ozone. The influence of relative humidity on the abundance of allergens, pathogens, and noxious chemicals suggests that indoor relative humidity levels should be considered as a factor of indoor air quality. The majority of adverse health effects caused by relative humidity would be minimized by maintaining indoor levels between 40 and 60%. This would require humidification during winter in areas with cold winter climates. Humidification should preferably use evaporative or steam humidifiers, as cool mist humidifiers can disseminate aerosols contaminated with allergens.

IMPACT OF HUMIDITY ON HEALTH

Drier conditions with low humidity can cause us to develop a range of problems due to our inability to absorb and retain sufficient moisture. The direct result of this is skin irritation, cracked lips, rashes, flaking, roughness, and eye irritation, the latter of which can develop into serious infections if not treated or rectified in time with proper. If the humidity in an environment declines to substandard levels, our nasal passages become drier. This can, in fact, worsen allergy symptoms and make those with allergies highly susceptible to feeling discomfort, irritation, and even developing sinus infections. On the flip side, high humidity encourages the development of mold, mildew, dust mites, and other allergens that can equally negatively impact our wellness and health. The air can become more difficult to breathe as well, which can result in the increased risk of an asthma attack and triggers for sufferers of the condition.

Sources of **Air Pollution**

What composes and amplifies indoor pollution? Hundreds of chemical, physical, bacteriological and allergenic compounds are the major pollutants.

Among the most common sources of pollutants are tobacco smoke, combustion processes, products for cleaning and maintenance of the house, pesticides, the use of glues, adhesives, solvents. Also the emissions of the materials used for construction and furnishing (eg furniture manufactured with chipboard, with plywood or with medium density wood fiber boards, or treated with pesticides, but also carpeting and coverings) can contribute to the mixture of pollutants present. The malfunctioning of the ventilation system or an incorrect positioning of the air intakes near areas of high pollution (eg high traffic streets, underground parking, garage, etc.) can cause an important penetration of pollutants from the outside .

Specifically, it is possible to classify the main causes of pollution within environments confined to six macro families.
First family: emissions by the materials.
Second family: production by man and his activities.
Third family: the atmosphere.
Fourth family: microbiological pollutants.
Fifth family: chemical pollutants.
Sixth family: physical pollutants.
Only some of the most interesting case studies will be used below

Figure 1.8: Atmosphere pollution

Emissions from material

Different polluting substances are emitted by the materials used in the construction and maintenance of building structures or installations; in particular the added chemical components to ensure better performance.
It should be noted that above all the furnishings increase the mixture of pollutants in the indoor air.
Furniture manufactured with chipboard, with plywood or with medium-density wood panels, or treated with pesticides, but also carpeting and coverings, release toxic and harmful substances in the air such as: VOC, formaldehyde, Radon, Asbestos and heavy metals : all carcinogenic pollutants.

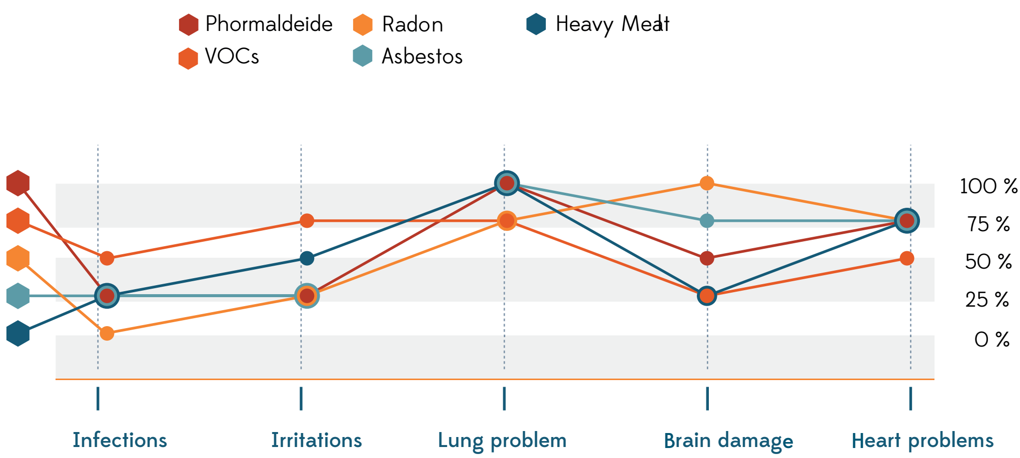


Chart 1.14: Sources of pollution and risk of disease from material

Emissions by man and his activities

Humans, with their activities and their normal metabolic processes, contribute to the emission of harmful substances in indoor air. The pollutants derive (as well as from man), from animals, plants, from activities that take place in environments and from air conditioning systems.
The most common sources of pollutants are: tobacco smoke, viruses and bacteria, molds and fungi, substances coming from detergents, insecticides and products for personal hygiene; products for cleaning and maintenance of the house, pesticides, the use of glues, adhesives, solvents and the use of work tools such as printers, plotters and photocopiers must also be included.
Furthermore, it should be remembered that the substances coming from the cooking of foods and combustions in general, such as PAHs - Polycyclic Aromatic Hydrocarbons, nitrogen oxides, carbon monoxide, VOCs, are all irritating and / or carcinogenic substances.

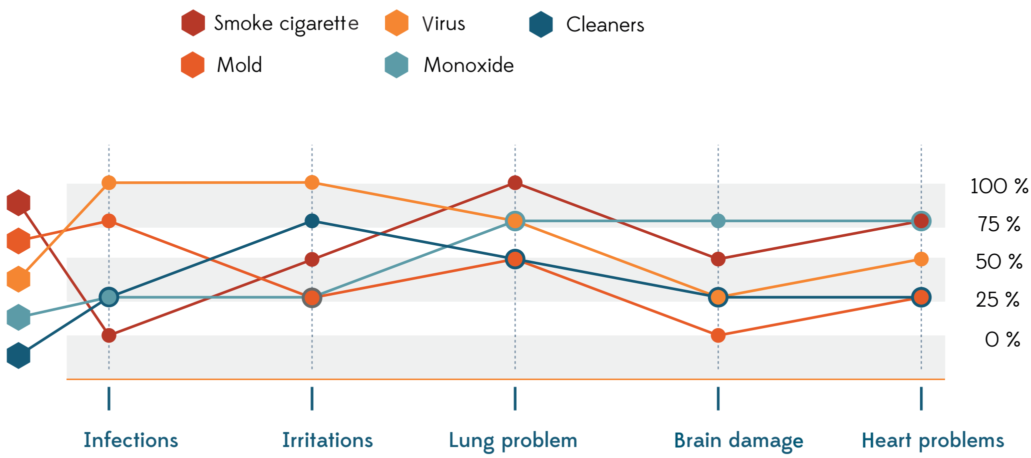


Chart 1.15: Sources of pollution and risk of disease by man and his activities

The atmosphere

There are numerous external polluting sources coming from the atmosphere. The compounds that contribute massively to air pollution - due, as is known, to the growing number of industrial and public and private transport systems - are mainly represented by: carbon monoxide (COx); Sulfur oxide (SOx) Nitrogen oxide (NOx) Volatile organic compounds (VOC) Total solid particulate matter (PST), Micro pollutants present in the atmosphere atmosphere.
And it should be noted that these are all irritating and / or carcinogenic pollutants.

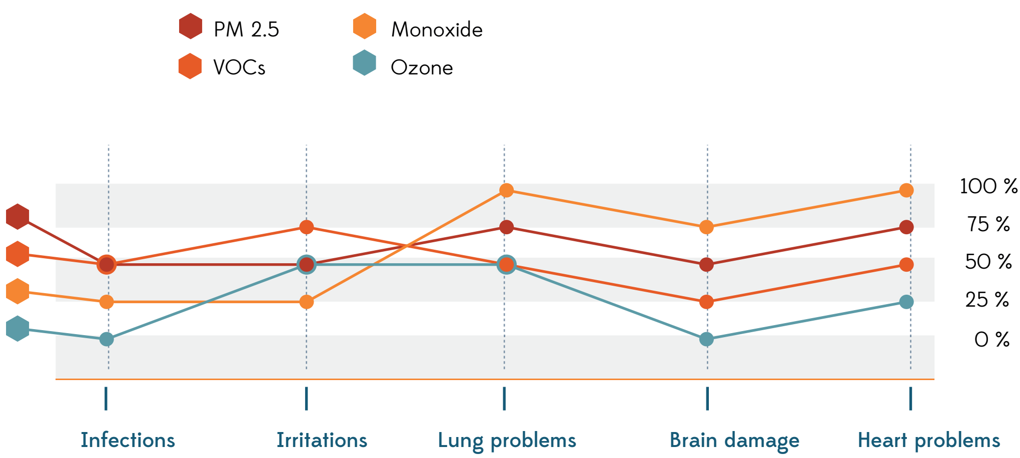
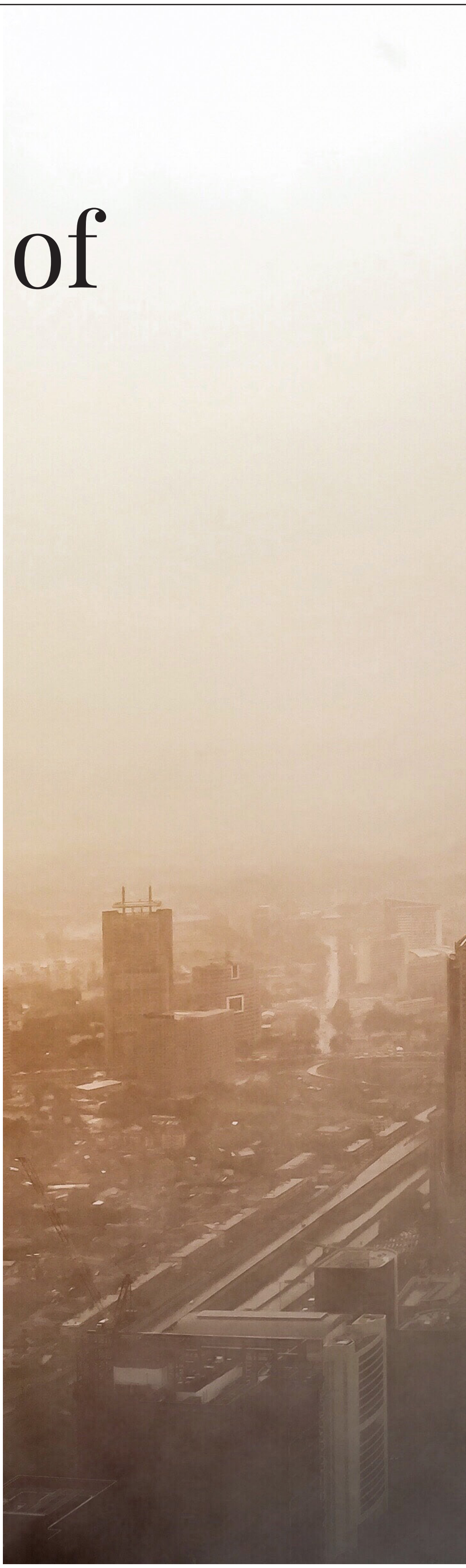


Chart 1.16: Sources of pollution and risk of disease from the atmosphere

Health effects of air pollution



Exposure to air pollution has health effects at every stage of life, from before birth into old age. The damage is sometimes gradual, and may not be apparent for many years.

Lung function naturally develops throughout childhood, and there is clear evidence that long-term exposure to outdoor air pollution suppresses this process. In addition, it may speed up the decline of lung function through adulthood and into older age.

There is also good evidence that outdoor air pollution causes lung cancer.

It is likely that long-term exposure to air pollution is linked to the development of asthma. For people who already have asthma, there's strong evidence that air pollution can make it worse.

We still need more research, but it's possible that exposure to air pollution could be associated with the appearance of diabetes, and may also damage the brain's thinking abilities (cognition) in subtle ways that build up over time.

The effects of ambient air pollution cannot be assigned to a single pollutant in the mixture. As in the case of tobacco smoke, many pollutants act together in a series of partly interrelated mechanisms, which result in the observed associations between levels of air pollution and a range of health outcomes.

Studies on the asthmatic population (mainly children), or those at risk of developing asthma, indicate positive associations between CO2 concentration and respiratory symptoms, including wheezing, breathing difficulty, chest tightness, shortness of breath and cough.

Exposure to volatile organic compounds (VOCs) may be related to a spectrum of illnesses ranging from mild (irritations) to very severe (cancer). Even the levels of exposure are relevant. In infants and children, exposure to VOCs increases the risk of respiratory and allergic conditions such as asthma, wheezing, chronic bronchitis, reduced lung function, atopy and severity of sensitisation, rhinitis and respiratory infections. Many of the effects observed in children have also been shown in adults.

Figure 1.8: City air pollution

Growing and aging lung

Maximising lung growth during childhood and minimising lung function decline during ageing are important because the development of low lung function (measured by spirometry as FEV and FVC) means that there is less reserve if lung disease develops.
Adverse effects of air pollution on the developing baby may have long-term effects on lung development during extrauterine life.
In schoolchildren, the effects of air pollution over time on the increase of FEV and FVC (as indices of lung function growth) have been examined in the Children's Health Study. This study recruited more than 11,000 schoolchildren selected from classrooms in 16 communities in California, USA.
Lung function was measured every year and long-term background levels of air pollution were measured. Suppression of lung function growth was found in children living in communities with the highest concentrations of PM10, PM2.5, elemental carbon and NO2.
Lung function in adulthood slowly declines with age. A recent analysis linked the long-term lung function of the adults with exposure in the home to air pollution, expressed as either distance of home from a major road or an exposure to PM2.5. This study found that adults living <100 m from a major road had a greater decline in FEV than those living >400 m from a major road.

It's clear that long-term exposure to either background or locally generated air pollution impairs lung function growth in children. Reducing exposure to air pollution reverses this effect, thereby allowing more young people to achieve their maximum lung function growth potential. In adults, there is emerging evidence that air pollution accelerates the decline in lung function during aging.

Significantly reduced lung function in adulthood if they live in highlt polluted areas.

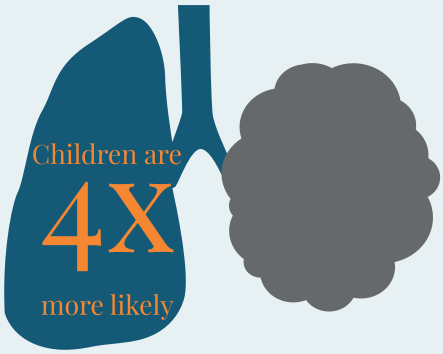


Chart 1.17: Growing and aging lung effect in children

Asthma and Wheeze

Asthma is a long-term inflammatory condition of the conducting airways of the lungs. It causes the airways to contract too much and too easily, leading to cough, wheeze, chest tightness and shortness of breath. It is a disease whose onset often begins in early childhood.

Asthma is potentially a life-threatening condition, with a high burden on health services and quality of life. There are over 5 million people in the UK who are currently receiving treatment for asthma, 1 million of these being children. The UK still has some of the highest rates of asthma in Europe and, on average, three people a day still die from asthma.

An analysis by Gasana of the effect of traffic-generated air pollution and asthma in children, which included 19 studies, concluded that:

1. increased exposure to CO_2 is associated with asthma
2. increased exposure to PM is associated with wheeze.

CO_2 is also generated indoors during gas cooking. In a meta-analysis of 19 cross-sectional studies on the effect of either indoor NO_2 or gas cooking and asthma, Lin et al19 found that gas cooking was also associated with increased risk of both current and lifetime asthma.

Cancer

Children

Cancer is rare in children, and the WHO reported in 2005 that there was 'insufficient evidence for ambient air pollution and childhood cancer'. Since 2005, studies on traffic-related air pollution and childhood cancers have produced equivocal results.

Air pollution exposures have been linked to lung cancer, but this is not a type of cancer generally seen in children. It is believed that the development of lung cancer after exposure has a long latency period; this could be 15, 20, even 30 years later. Therefore, exposure of children to high levels of air pollution could contribute to the development of cancers in later life.

Adults

Two American studies (the American Cancer Society Study and the Six Cities study) in the early 1990s were the first studies to show associations between long-term exposure to air pollution (specifically PM) and deaths from lung cancer.

The ESCAPE study found that PM contributes to the incidence of lung cancer in Europe.Based on such studies, the International Agency for Research on Cancer (IARC) classifies outdoor air pollution and PM from outdoor air pollution as carcinogenic to humans .They concluded that there is strong evidence that exposures to outdoor air pollution are associated with changes in gene expression and genetic damage, which are linked to increased cancer risk in humans. They further state that there is 'sufficient evidence that exposure to outdoor air pollution causes lung cancer.

Need-finding

From the data emerged from the research phase, it is clear that the problem of indoor air pollution is a serious problem for the society. This problem is strongly highlighted in the western states and only nowadays it start to worry Europe.

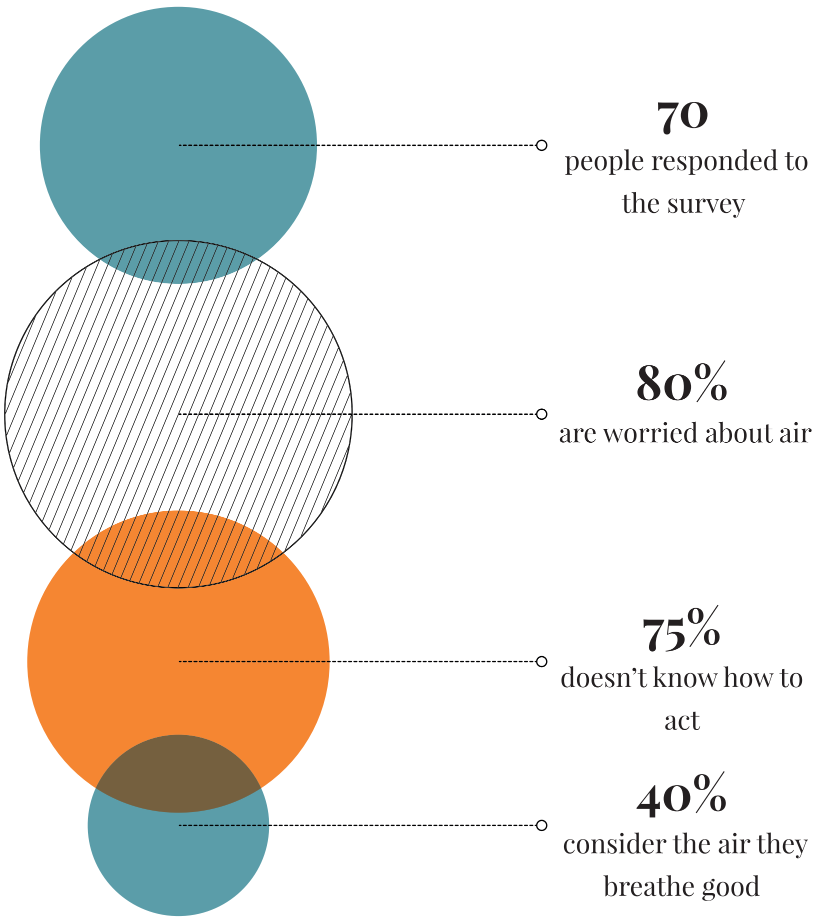
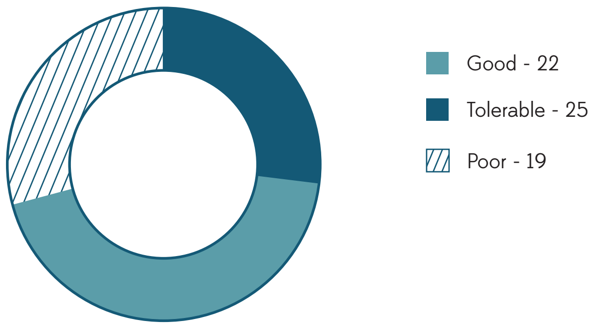


Chart 1.18: Data analysis of the survey result

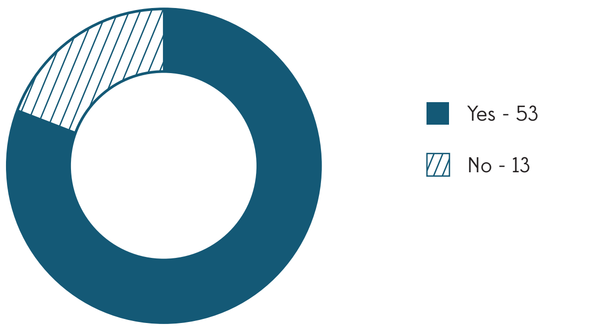
Introduction

To better understand how users see and act with this problem it is necessary to interact with them through a survey.
It has been proposed and advertised on different sites of virtual communities of environmental protection, with the aim of using their enthusiasm to obtain useful information deriving from the experience of each of them. The hope was also to obtain a rapid and widespread distribution of the questionnaire in order to have a valid sample to have significant results.
The time required is only 5 minutes, a very important factor if you do not want to generate discontent in the user who could get bored and respond impulsively, thus generating false results.
The sequence of questions has been carefully studied.
The first questions are used to generate a data collection of data on age, sex, occupation and in what kind of area they live. We then move on to questions whose answers aim to verify the actual knowledge of domestic pollution, in order to understand if the user is actually aware of the problem and possibly for what reasons it does not act.
The central part of the survey focuses instead on the use and frequency of air monitoring devices. In the final analysis, the user was given the opportunity to express what the fundamental aspects were in a pollution control device.
To be fair it is good to specify that the response, in terms of number, of these communities has proved to be well below expectations, allowing the collection of only 70 completed questionnaires in their entirety.
If it seems that the sample is not that significant, you will see how the answers obtained outline a clear problematic situation in the home.
To whom who wrote "the conviction is deeply rooted that to design a product for the user, there is no better way to do it than with the user himself."
Below you will find the list of questions asked in the questionnaire with the respective answers:

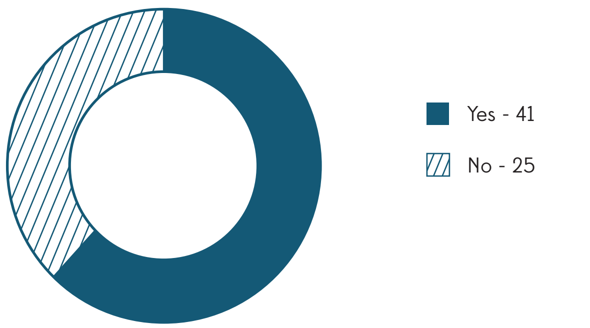
How would you describe the air you breathe?



Are you worried that air quality affects your personal health?



You know that we spend about 90% of our time in indoors environment.
They can be up to 5 times more polluted than the outside.



If you find a high rate of pollutants (NO2, VOC, CO, PM 2.5) in a domestic environment, would you know how to intervene?

What aspects do you consider fundamental in an anti-pollution device?

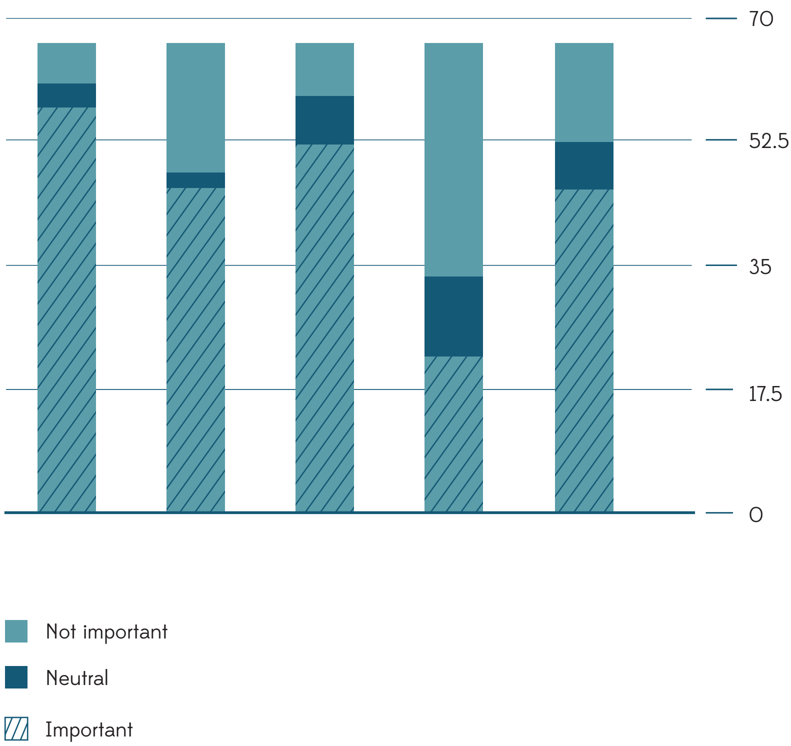


Chart 1.19; 1.20; 1.21; 1.22; 1.23: Result from the survey

Existing Solution

It is right to tackle the problem not only by waiting regulations that limit the control of pollutants, but also try to understand how the products on the market can help.

To carry out an effective comparative analysis, it was necessary to develop the benchmark by identifying 3 macro areas: Home appliance, Dongle and Air monitoring

THE SUBJECTS OF THE ANALYSIS

The research begins by analyzing and cataloging the devices or services concerning the three focuses (home appliance, dongle and air monitoring) and inherent to the home ecosystem. After all the results a grouping operation was carried out for common factors that allowed to highlight the performances and to skim, eliminating subjects that, even if interesting, did not meet the basic requirements to perform a comparative analysis.

THE PARAMETERS

Each of the analyzed objects has been given an overall judgment, to have a global feedback on its performance and to make immediate understanding of its efficiency.
This judgment was attributed considering several factors, including the tops and flops, the best and worst features, but above all a systematic evaluation was carried out considering 5 parameters: effectiveness, autonomy, integration, innovation and technology.

Glossary

MACRO AREAS

Home appliance:
Home appliance: this category includes all the devices that interact by supplying, recycling or subtracting air.

Dongle :
is a small piece of computer hardware that connect to a port on another device to provide it with additional functionality, or enable a pass-through to such a device that adds functionality

Air Monitoring:
are part of this group all the devices that allow air quality monitoring.

PARAMETERS

Efficiency:
the ability to fight pollution

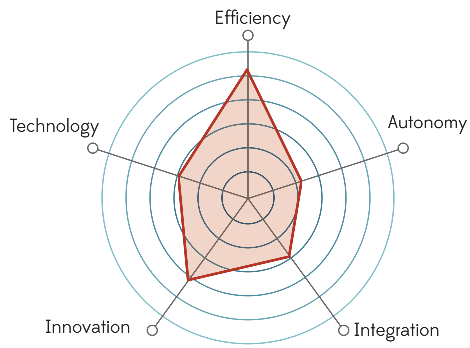
Autonomy:
being able to act independently

Integration:
possibility to interact with other devices

Innovation:
introduction of considerable innovations for the reference sector

Technology:
application of new technologies.

Home Appliance:



SAMSUNG WALL-MOUNT (AIR SUPPLY)

PRO:

Filters for PM 2,5 ; App for remotely control

CONS:

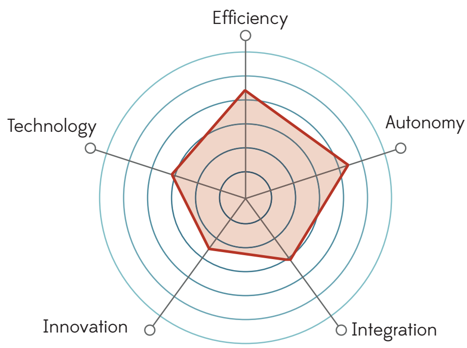
No integration with smart home devices , Just for the closest room

All products that, following a cooling or heating treatment, add air to the interior of the home belong to the category. There are mainly two types of products and they are: Air conditioners, convectors.This range of products has been strongly influenced by environmental pollution; today important companies in the sector apply filters to reduce the level of PM to their devices.

The Korean company Samsung has recently introduced the Samsung Wall-mount air conditioner. With the Wi-Fi Control using a Smart Home App you can remotely control the functions and schedule its operation. It also gives you live feedback about how it's operating and lets you monitor and limit power usage.

It helps to keep the air you breathe pure and healthy. A Easy Filter captures dust, dangerous contaminants and allergens*. And Ionizer reduces certain harmful viruses and bacteria by up to 99%.

Figure 1.9: Samsung Wall - Mount
Chart 1.24: AC Radar, benchmark



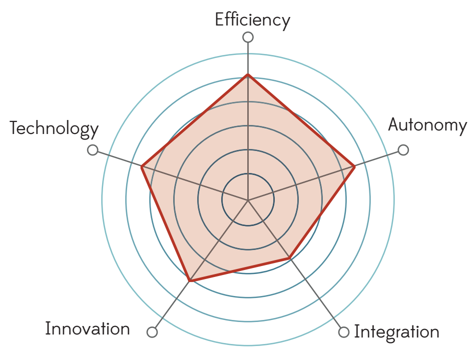
VELUX INTEGRA
(AIR EXPULSION)

PRO:
Autonomous cleaning

CONS:
Low efficiency, I don't know if the outdoor pollution is higher of the indoor, Just for roof widow

For a proper air recycling studies show that ventilating the room for 5 minutes at least 2-3 times a day creates benefits. Products such as fans and windows, if opened in certain periods of the day, therefore favor correct air recycling.
Velux Integra is a system that allows you to open and close windows, curtains and shutters with a simple touch. The VELUX sensor control with NETATMO contributes to a healthy environmental climate in a completely automatic way. The sensors measure the temperature, the CO2 content and the humidity of the air, controlling the roof windows, and provide accordingly.

Figure 1.10: Velux Integra
Chart 1.25: Air Expulsion Radar, benchmark



DYSON PURE COOL (AIR RECYCLING)

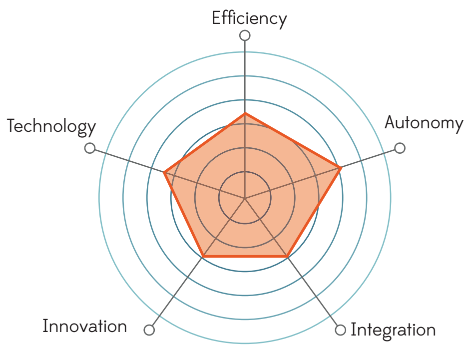
PRO:
Autonomous cleaning, High efficiency

CONS:
High price, Just for the closest rooms, I don't know what happens when it cleans

An air purifier is a small appliance capable of cleaning the air of indoor environments, through a purification system based on a fan, filters and other technologies such as ionization and UV rays. Air purifiers can drastically reduce the presence of bacteria, pollen, mold, fine dust and other particles.
The Dyson Pure Cool air purifier stands out for its high performance, both in the air purification phase. In addition, the Dyson Pure Cool air purifier is a fully connected and smart product. Thanks to Bluetooth and WiFi connectivity, it is possible to manage it remotely and monitor the air quality of your home at any time.
Thanks to the integrated sensors it is the only one in this category to have the automatic mode, with which you can let the product take care of your home. The sensors are very precise and are able to detect PM 2.5, PM 10, organic particles and nitrogen dioxide, as well as all other types of potentially harmful particles.

Figure 1.11: Dyson pure cool
Chart 1.26: Air Recycling Radar, benchmark

Dongle:



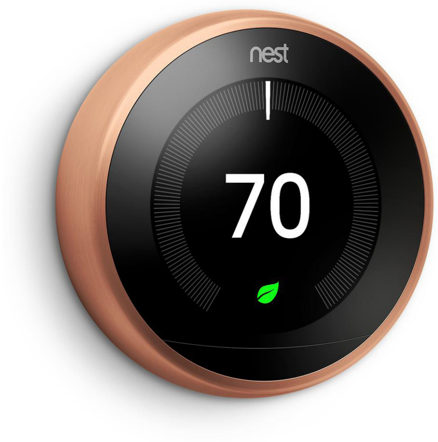
TADO

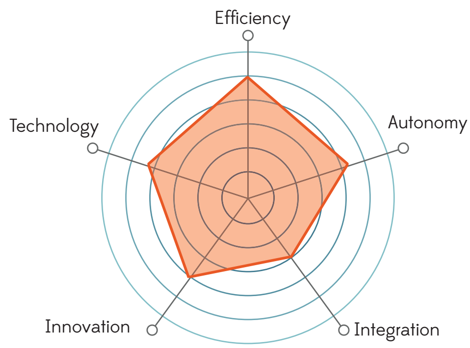
PRO:
AI to lear the routine, Geolocation for turning on-off, Smartphone and physical interaction, Combine data from outside, Open window detect, Infrared communication

CONS:
Interaction just with AC, New version of AC already have this function

Tado is a device that allows you to replace the remote control and control your air conditioner at any time and place.
Tado's sensors and live data will help create a personalized Comfort Profile, to optimally adjust your environment based on you. Simply interact with the in-app feedback interface to indicate your comfort level; Tado's AI will learn from you to continuously auto-adjust your AC and cater to your needs.
Intelligently switches your AC based on your pre-set radius, or automatically turns it off when you leave, using geofencing and your phone's location,

Figure 1.12: Tado
Chart 1.27: Tado Radar, benchmark





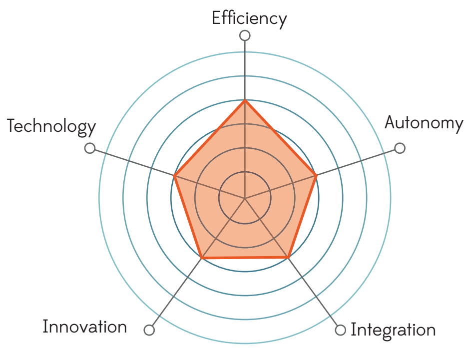
NEST:

PRO:
Eco function, AI to lear the routine, Very easy smartphone and physical interaction, Proximity sensors, Wireless communication

CONS:
Connection to the thermostat is not easy, It only integrates with boilers

Nest is a thermostat that learns to recognize the temperatures you prefer when you are at home and then program yourself. When you're not there, it automatically warms up to help you save energy

Figure 1.13: Nest
Chart 1.28: Nest Radar, benchmark



SOMFY PROTECT HOME:

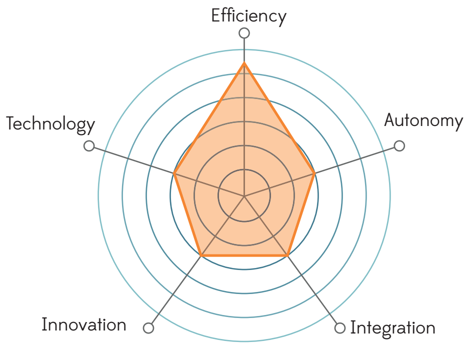
PRO:
Easy installation, Routine, No wire for the sensor, Wireless communication

CONS: -

A range of products that, although they do not deal with the quality of the environment, are of great interest are the Smart Alarms.
The Somfy Protect Home home burglar alarm is designed to guarantee reliable security that can be easily installed. Wherever you are you can manage the security system of your home; it is also able to recognize "ordinary" events such as a ball bouncing off the window to avoid creating false alarms.
Thanks to the ULE technology (Ultra Low Energy) it guarantees a long life of the sensor battery.

Figure 1.14: Somfy protect home
Chart 1.29: AC Radar, benchmark

Air Monitoring :



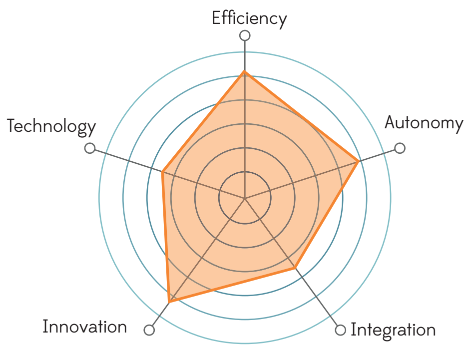
UHOO

PRO:
High Reliability,

CONS:
Just the data from one room, No external air quality, No suggestion, No connection with other device

Uhoo is currently the most complete monitor of air quality from the point of view of the sensors, which are as many as 9: fine particulate matter (PM 2.5), volatile organic compounds (VOCs), zero dioxide (NO2) ozone (O3) , carbon monoxide (CO) carbon dioxide (CO2), humidity and temperature. Thanks to the compatibility with the smartphone it provides real-time weather data. The app will alert you when the air goes bad in a room.

Figure 1.15: Uhoo
Chart 1.30: Uhoo Radar, benchmark



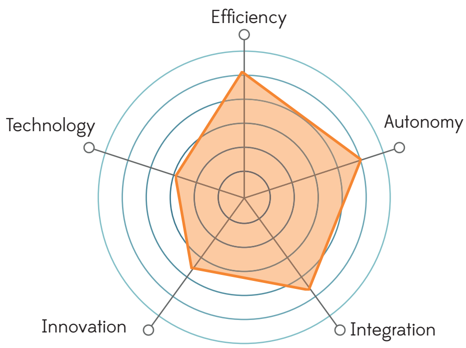
PLUME

PRO:
Smartphone and visual Notification, Easy to carry.

CONS:
Low battery

Flow is the intelligent device that fits into your daily life and helps you make the best air quality choices for yourself, your family, your community. The press of a button illuminates animated LEDs, giving you immediate feedback on what your air's like–indoors, outdoors, on a bike, riding the subway, or strolling through the countryside.
Thanks to our pollution alerts and smart notifications, you'll have access to critical air quality forecasts exactly when you need them.

Figure 1.16: Plume
Chart 1.31: Plume Radar, benchmark



AWAIR

PRO:
High Reliability, Connection with other device, Suggestion

CONS:
Just the data from one room, No external air quality

Bitfinder Awair is one of the best-known names in indoor air quality monitors. It is a device capable of perceiving volatile organic compounds (VOCs), fine particles (PM 2.5), CO2 sensor and thermometer.
It's a smart device that can connect to Google Nest, Amazon Alexa, and other IFTTT devices. The app provides useful and personalized suggestions based on the relative data of the house, so you can learn everything about each data and how you can improve the quality of the air.
Awair is the only one of its kind that is able to connect to other intelligent air quality devices to adapt to the prevailing conditions.

Figure 1.17: Awair
Chart 1.32: Awair Radar, benchmark

Brief

Thanks to the material collected and processed during the research phase, it was possible to map the problems related to indoor pollution in a clear and synthetic way.
The information gathered allowed to outline the road to be taken for the design phase and led to the creation of a Project Brief.

Figure 2.1: Air pollution inside home

The Opportunity

Research summary

The collected material needs to be re-elaborated in order to map the problems related to indoor pollution in a clear and explicit way. This phase will direct the path to take for the design phase, managing to bring out the ideas, insights.
The itinerary undertaken highlighted a large gap in the home environment, which is converted into a design opportunity.

AIR POLLUTION

The air pollution is become a global concern. It has been proved that human society is directly responsible of the increase of pollutant emissions on the atmosphere.
Air pollutants can be gas, solid particles, or liquid. They can be the result of the production of natural processes or human activities. Pollutants are classified as primary or secondary.
According to the last report of the European Environment Agency, (EEA, 2018) 9 out of 10 citizens are exposed to excessive levels of PM2.5.
The World Health Organization estimates that, Outdoor air pollution is responsible for the premature death of over 3 million people worldwide each year, over 83 million years of life lost each year.
These values, however, grow considerably, up to 7 million premature deaths, including the effects of indoor pollution.
The victims caused by air pollution is about 20 times that of victims of road accidents.
The cost related to the health impact were between 330 and 940 billion euros: these are values ranging from just under 2% to 6% of European GDP.
The study of L"im et al" found that household air pollution from fuels remains one of the three leading risk factor for global disease.

THE INDOOR GENERATION

You are probably spending more time indoors than you think. Studies have shown that the average person actually spends a whopping 90 percent of their time between four walls.
The truth is that most of the people didn't even realize that all that time indoors has a detrimental effect on our health and well-being, similar to poor diet or lack of exercise. They are also unaware that pollution is often worse indoors than outdoors. 8 out of 10 people are unaware that indoor air can be up to 5 times more polluted than outdoor air.
The superficial information at the level of the designer and the user is the biggest problem

INDOOR POLLUTANT

More than 900 different compounds are present in indoor air.
We can found: natural pollutant (normal metabolic processes, personal care products, pets) or man-made pollutant (smoking of cigarettes, combustion appliances, cleaning and DIY product, air fresheners...)
According to the European INDEX the most significant pollutantsin terms of health impact are Volatile Organic Compounds (VOC), Carbon dioxide (CO2), Particulate Matter PM.

VOC: are emitted to air as combustion products, as vapor arising from petrol, solvents, air fresheners, cleaning products, perfumes. They can cause inflammation of the respiratory tract, eyes, nose and throat. A dangerous VOC is formaldehyde.
Range VOC: <100 mg/m3

PM2,5: particulate matter are microscopic solid or liquid . Particulate matter can be classified according to the size of the particles; fine particles, with a diameter of 2.5 micrometers or less (PM2.5). They are the result of human activities, such as the burning of fossil fuels. One group of particulate matter identified, PM2.5, have small diameters, however large surface areas and may therefore be capable of carrying various toxic stuffs, passing through the filtration of nose. PM 2,5 cause 340,000 life years lost.
Range PM2,5 : <50 mg/m3

CO2: A colorless, odorless gas at room temperature, carbon dioxide is an abundant substance. When humans breathe out, carbon dioxide is expelled. Carbon dioxide builds up in a house, whether from the gas being drawn up from the soil or from the activities of humans and pets.
Range CO2 : <1,000 ppm

CO: Carbon monoxide is a colorless, odorless, and tasteless gas that is slightly less dense than air. It is formed when a stove or a combustion engine is used in an enclosed space. Carbon monoxide also forms a pollutant when hydrocarbon fuels are burned. Carbon monoxide poisoning typically occurs from breathing in too much carbon monoxide. The most common symptoms are headache, dizziness, nausea/vomiting, confusion, fatigue.
Range CO: < 25 ppm

Humidity and temperature: also affect indoor health. Home humidity levels should not exceed 40-60% High temperatures and humidity can promote the growth of mold, bacteria and fungi that are harmful to health and are often not visible to the naked eye.
Range Humidity: 40-60%
Range Temperature: 20-22°

SOURCE OF AIR POLLUTION

The indoor pollutants are numerous and can be originated from different sources.
Among the most common sources of pollutants are tobacco smoke, combustion processes, products for cleaning and maintenance of the house, pesticides, the use of glues, adhesives, solvents. Also the emissions of the materials used for construction and furnishing can contribute to the mixture of pollutants present. The malfunctioning of the ventilation system or an incorrect positioning of the air intakes near areas of high pollution can cause an important penetration of pollutants from the outside
From how we understand the sources of pollution are potentially everywhere in the house.

HEALTH EFFECT

Exposure to air pollution has health effects at every stage of life, from before birth into old age. The damage is sometimes gradual, and may not be apparent for many years.
The effects of ambient air pollution cannot be assigned to a single pollutant in the mixture. The main causes are:

Lung function naturally develops throughout childhood, and there is clear evidence that long-term exposure to outdoor air pollution suppresses this process. In addition, it may speed up the decline of lung function through adulthood and into older age.

There is also good evidence that outdoor air pollution causes lung cancer.

It is likely that long-term exposure to air pollution is linked to the development of asthma. For people who already have asthma, there's strong evidence that air pollution can make it worse.

NEED-FINDING

A fundamental help was to contact users through the use of questionnaires.
From what emerged 80% of people are worried that the quality of air can affect their health, but, confirming the research data, they do not know how to avoid it and how to intervene.
Although, from the answers collected, only 9% have a device for monitoring pollution, as much as 77% have shown interest in a device that guarantees correct air quality.
Take preventive action and suggestions to improve the environment was among the parameters considered fundamental.

EXISTING SOLUTION

To carry out an effective comparative analysis, it was necessary to develop the benchmark by identifying 3 macro areas: Home appliance, Dongle, Air Monitoring. Each of the analyzed object has been given an overall judgment.
Today the problem of pollution can be solved by using multiple devices, all with great potential but which must be enabled.
However, numerous gaps have emerged especially in the air monitoring market; most of them are not able to connect with devices already present, even if I am warned of the presence of a high pollutant I am not informed about how I can prevent it or defeat it; data is only taken in one room and this cannot guarantee good air quality throughout the house, the devices do not take into consideration the quality of the outdoor air.

Problem setting

Based on user input and the research phase it was possible to identify the major problems related to high indoor pollution.

First of all, the number of pollutants in an indoor environment is high, it is estimated that there are around 900 of them in the house, and although only 5 of them are considered among the most dangerous, it is difficult, if not impossible, to undertake a universal action, which can satisfy all user needs.
In a perspective in which the polluting particles are strongly linked to the activities that are carried out within the indoor space, users will have different needs, devices and remedies.

Disinformation is one of the key aspects. As was demonstrated during the research and confirmed in the survey phase, one person in two believes that home air is better than outside, and only 14% understand the effects of indoor pollution on well-being.
However, being aware of the risk is not enough, it is of fundamental importance to know the methods and devices it is possible to get rid of these pollutants.

There are many solutions on the market and these are undoubtedly destined to increase; important companies operating in the sector are directing their resources towards this issue.
Products dedicated to air treatment presented large gaps, they, although they may be present throughout the home and may be able to activate at the right time, are unable to communicate with each other.
In recent years it is much more likely to find an air monitor inside the houses, but these are not able to communicate with the environment and with the devices present. Their goal is to provide a sporadic datum and, given that the user is not aware of how to intervene, their function remains to provide a datum.

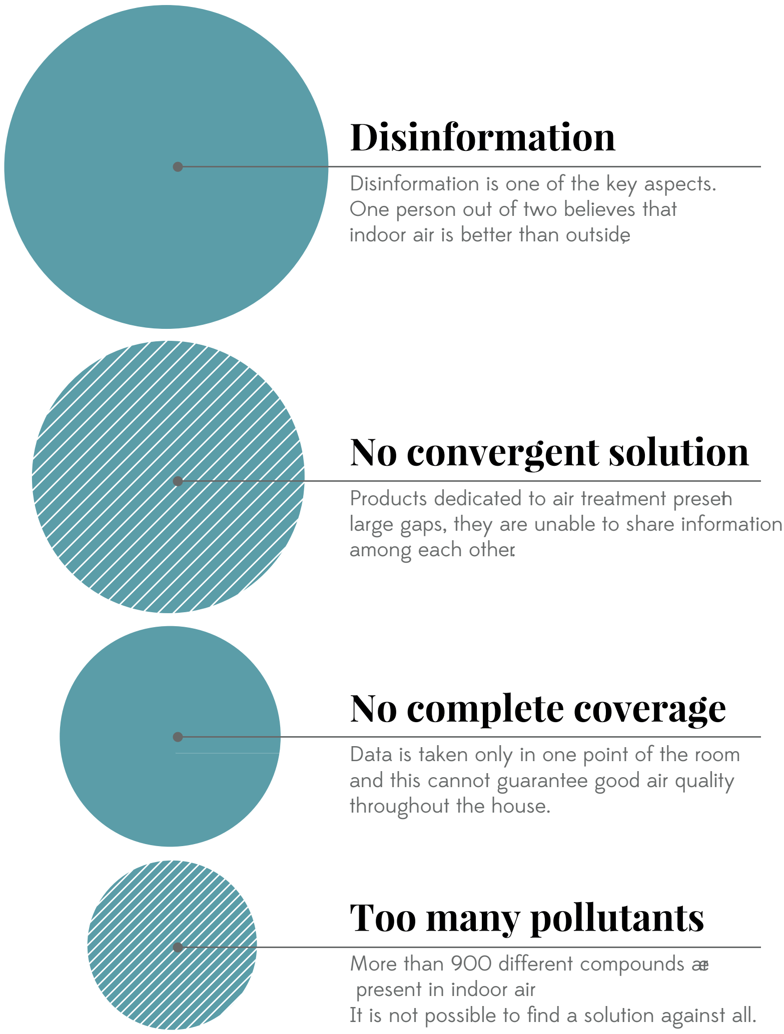


Chart 2.1: Problem setting visualization

Briefing

Brief

In order to correctly go from a research phase to a concept phase, it is necessary to draw up a design brief. It contains the information obtained from the analysis, which is transformed as requirements that the project must meet.
At the end of the research it is clear that devices already present in the houses have a potential that must be used in the correct circumstance.
The proposed concept must be **“a product that guarantees a healthy environment. That is able to carry out an accurate measurement of air quality at strategic points in the environment to develop the best solution. “**

The main points that are considered fundamental by users are the ability to prevent pollutants and autonomy in the purification process.
Preventing a pollutant is almost impossible, as until an event has occurred that releases pollutants, preventing their spread is not possible.
A reading perspective of prevention can be considered information. Informing a user about how to avoid and how to get rid of domestic pollution can bring significant improvements to the user’s habits to the advantage of a lower level of pollution.
The autonomy of the purification process is the capacity according to which the system is able to develop the best solution for that specific problem. He will be able to understand in which area and with which device it is better to intervene.

Chart 2.2: Key point of the product

"

A product that guarantees a healthy environment. It will able to carry out an accurate measurement of air quality at strategic points in the environment to elaborate the best solution.

Project Requirement

To identify the best solution to reduce indoor pollution, three aspects must be taken into consideration and how they interact with each other, they are: user, environment and technology.

01

User:
as previously mentioned, certain pollutants appear based on the activities performed.
One of the main requirements is that the product must be able to inform the user on how to improve their lifestyle and how to prevent pollution.
It will be necessary to find a direct communication method.

02

Integration with environment:
a solution will be elaborated that takes into consideration how the environment and its possible barriers can modify the reading of data and the spread of pollution.
To guarantee a correct evaluation it will be important that the data is collected on the whole housing system and not in a specific point.

03

Integration with Technology:
the device must be able to configure itself both with the user and with the products already present in the environment, using existing technologies,

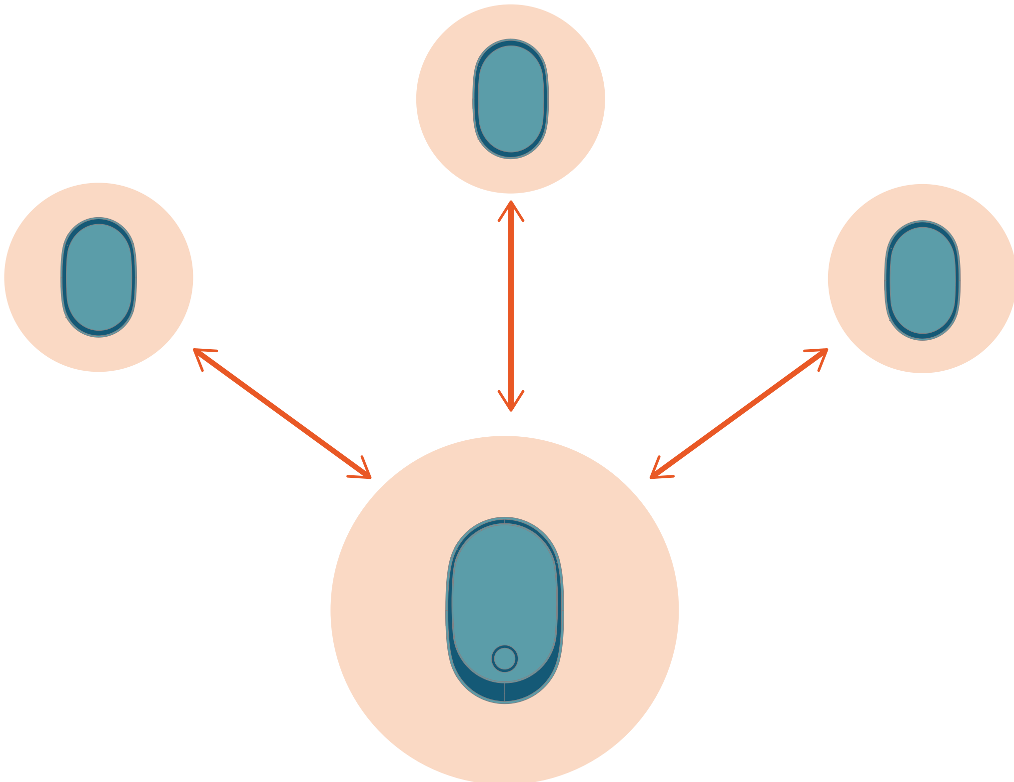
User X Environment X Technology

Chart 2.3: Project Requirement

From **concept** to **design definition**

Concept

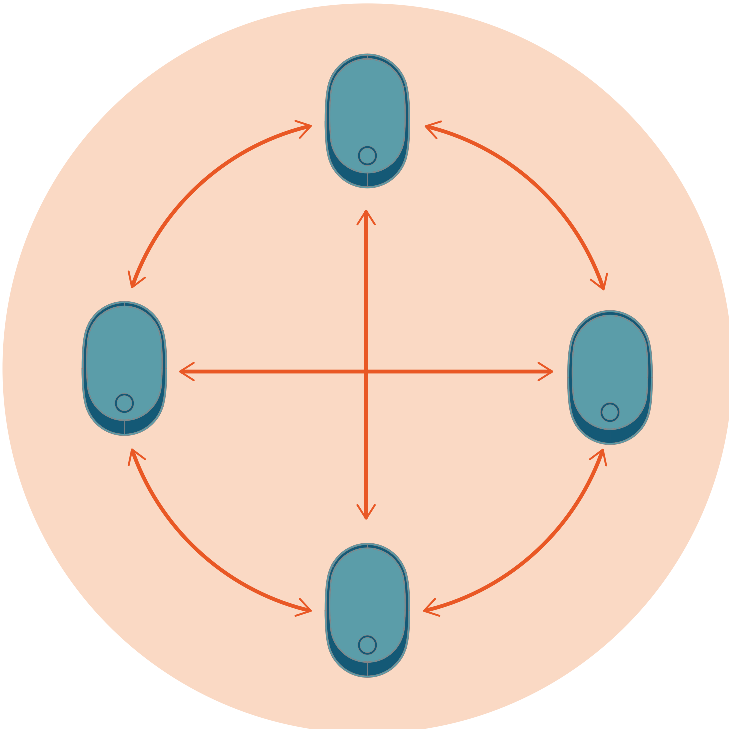
During the definition and development of the concepts, all possible solutions that could meet the requirements of the brief just listed were taken into consideration.
From the analysis carried out previously it is clear that the reading of a datum within a housing system is not sufficient for a correct assessment of the pollution level. In order to be able to identify the most polluted area, it is necessary to use different devices that will have to be positioned in strategic points of the house.
An aspect that has been a matter of analysis is the type of product configuration.
The alternatives that have been put forward are, in a server based model, and a second one composed of a system called peer to peer.
The two operating principles will be discussed below.



SERVER BASED

The server based system consists of a central hub to which secondary devices called Slaves are connected. The central hub is designed to be located in a central environment, it is the main device with which the user interacts. Being positioned in a strategic position it is equipped with a greater number of pollution sensors. The "slave" device designed for secondary environments (bedroom, bathroom). To ensure a healthy environment and complete automation, it detects an excess of pollutants and through an infrared connection is able to activate the device connected to it.

Chart 2.4: Server Based configuration



PEER TO PEER

The peer to peer system is based on an equal level of importance of each device. It was designed to ensure that there is no scalability limit. It is composed of different devices, according to their needs, which communicate with each other with the same degree of importance.
The user is able to interact with every single point of the chain.
Although the cost is greatly influenced, the product will therefore have greater reliability in reading the polluting parameters.

Chart 2.5: Peer - to - peer configuration

Concept Evolution

In order to advance in product development it was necessary to identify critical points and strengths of the two concepts.
Identifying an area that is defined as strategic, for Hub positioning, appears to be a difficult choice as it is not possible for a user to judge which area is better to have more detailed values.
Having the ability to interact only with a device (Hub) that, most likely, is not always placed near the user, making this interaction useless.
The devices must be able to communicate with each other reciprocally in order to develop the best solution. With a server based configuration, the slaves could not exchange information between them.
Once it was established that the peer to peer system would better satisfy the design requirements, various hypotheses were put forward on how to insert the product in the domestic environment.
The evolution of the product has been constrained above all by the environment and the type of interaction with the user.
Designing a device for home use imposes numerous design limitations; given the configuration, for which it is necessary to have a multitude of products within the environment, it does not want to be the protagonist, but to enter into harmony with the home.
Thanks to the peer to peer system it is possible to interact with every single device, making each environment important.

Project

In this chapter the product will be described in every single aspect, focusing on the explanation of the functional aspects of the object, in order to clarify any superficial aspect.
We will see the main components and in particular the way they interact with each other, up to the engineering phase.

Figure 3.1: Clean Air

Air Things

Description

The Air Things project is an air quality monitoring device, capable of measuring atmospheric concentrations of PM2.5, VOC, CO_2 and CO and temperature and humidity values.
It is an intelligent system that is able to use the potential of your devices to improve the quality of your indoor environment.
Air Things lets you learn all about each piece of data and how you can improve the quality of the air in your home.
The device represents an ideal solution to monitor every space of the home environment, thus ensuring the possibility of acting effectively in any given room.

Figure 3.2: Air Things

The user has the possibility to connect several Air Things between them. They can be placed in the same house, office or home. This allows you to place Air Things in different rooms of your home to ensure constant monitoring of all activities.

Unlike the air monitors present on the market, Air Things provides the user with advice on how to improve the environment.

It take into consideration the environment and the home applaiance present in your house to develop the best solution.

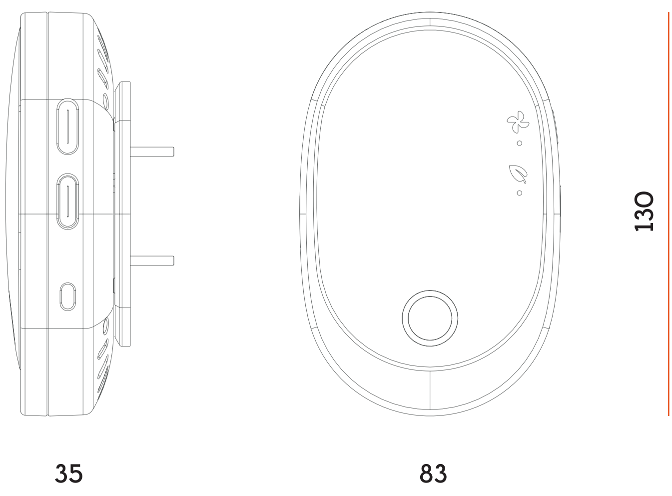
These tips are designed to improve the user habit, offering them solutions based on different activities.

PRODUCT ARCHITECTUR

Figure 3.3: Product Architecture

The device has been developed to have a high ease of use. You will only be shown air statistics in your home in real time.
The goal was to be able to communicate to the user only the strictly necessary data and that he is able to interpret you.
To do this, an LCD display has been introduced on the device at the front that uses a code system to indicate the current air quality levels. A good compromise is provided by the use of the Air Quality Index (AQI) values, as they, although not being the most reliable value, are able to outline a trend in air quality.

To make the communication even more direct, a LED system was introduced; it is designed to change color in order to indicate air quality levels. This simple design makes it very easy to understand and use. Through the use of red and green, the user will soon learn to distinguish good air quality from bad quality.
Thanks to the integration with the app, it allows you to check every single value. Here you will find all the extended readings of air conditions, including historical data. These are stored in the cloud so that you can later recover them from another mobile device.



ECO & AUTONOMOUS

The question that led to the development of these two modalities was: If the device guarantees the autonomy of the house why should I interact with the environment?
The product was developed to interact not only with domestic technological elements but also with the environment itself.
From how it emerged during the research phase one of the main requests made by users was that related to suggestions on how to improve the environment.
To make this possible, two Eco and Autonomous performance modes have been developed.
By pressing the two side buttons the user will decide which works best meets his needs.

The **Eco mode** has been designed in case you want to prefer user interaction with the environment, opening doors and windows, in a specific configuration, in order to optimize air recycling (it is estimated that, if carried out in correctly, on average 5 minutes is sufficient for complete air recycling).
Thanks to the App it will be advised which remedies can be made.
The eco function is designed to reduce the activation of devices to optimize energy consumption.
If we leave the house, or we prefer to open the window instead of using the device, or we don 't have devices connected in one place in the house,
In the case of a user without air handling devices connected to Air Things, the system will always be considered as an echo function.

The **Autonomous** function uses the potential of connected devices to always guarantee a high quality of air.
When you return home you will always find a clean air.
Thanks to its Peer-to-Peer configuration it is able to intervene in specific environments with targeted actions. The autonomous function has been designed for those who have a discreet supply of products for air treatment available; taking into consideration how the market for these products is developing, they will most likely be increasingly connected to each other.

Figure 3.4: Product inside an home

GEOLOCATION

The use of an App to manage every room in the house can be exploited to implement some function of the product.
One above all is the use of the geolocation of your phone. It turns out to be very useful when we approach or move away from home.
If a warning is sent to the system for which we have moved away from the house, it activates the ECO function, thus avoiding unnecessary current waste. Even if the pollutants are strongly linked to human activities, an alert state can occur when I immediately leave the house following an action of mine (cleaning, deodorants) and it would involve the activation of a device.
If instead a warning is sent to the system for which we are near the house it activates the AUTONOMOUS function, in such a way as to guarantee a healthy environment when returning home.

OPEN WINDOW DETECT

Air Things detects the opening of a window and allows you to switch off any devices without effort.
Once the window is open, the device detects the change of air and therefore interrupts any cleaning cycles.
The device is based on changing the values of the pollutants, if they are decreasing it means that an action has occurred that is changing the quality of the air. If this action has not been activated by Air Things if an air cleaning cycle is in progress it will interrupt it.
The activation of a device via a remote control can affect the change in air quality, the Ait Things system understands that, not having activated it, it cannot intervene.
Therefore in any case an action takes place outside the Air Things, he will not be able to intervene on them but rather, if these actions improve the quality of the air he will be able to interrupt any cleaning cycles.

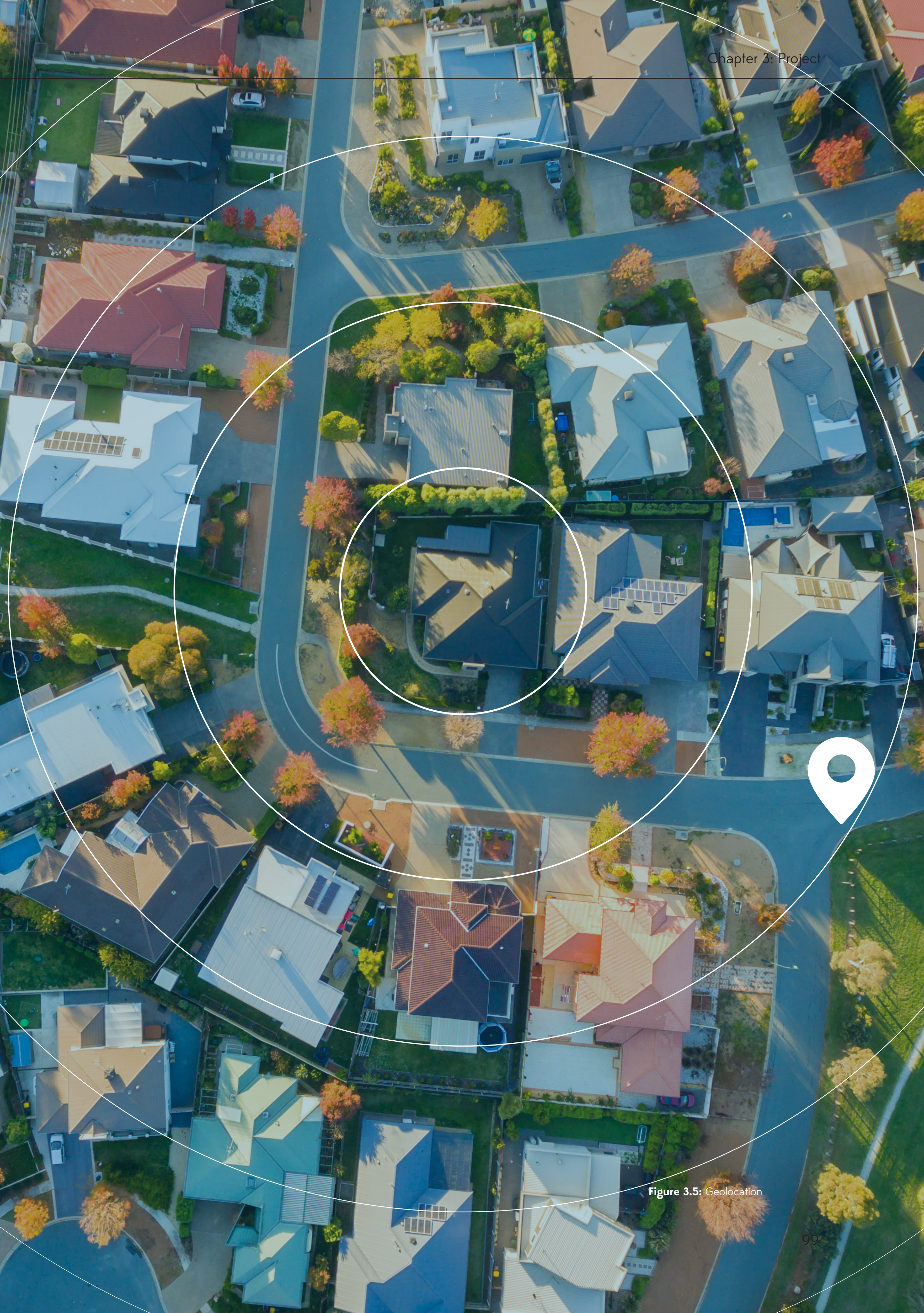


Figure 3.5: Geolocation

Connection

Make the best use of your devices for an "always on" experience. The product is continuously adjusting itself based on the users activities.

The product is based on three connection levels: Devices-Air Things, Air Things-Air Things and Air Things-User

The type of connection that allows the activation of the air treatment devices uses **infrared**; this is because you can use the connection channel of the remote control to activate them. A great limitation of this technology is represented by the possibility to activate only devices with remote controls.

Using infrared it can enable: Ventilation units, Filtration devices, Air ducts, Air conditioners, Air purifiers, Air humidifiers and dehumidifiers.

Devices that have a **Peer-to-Peer** configuration need to exchange information between them in order to work out the best solution.
The choice to install the Raspberry card on each device guarantees Wireless communication.

The connection between the **device and the user needs** to rely on the network in order to communicate the values of air quality through the app. To do this, the Raspberry component that supplies the Wi-Fi module is used.

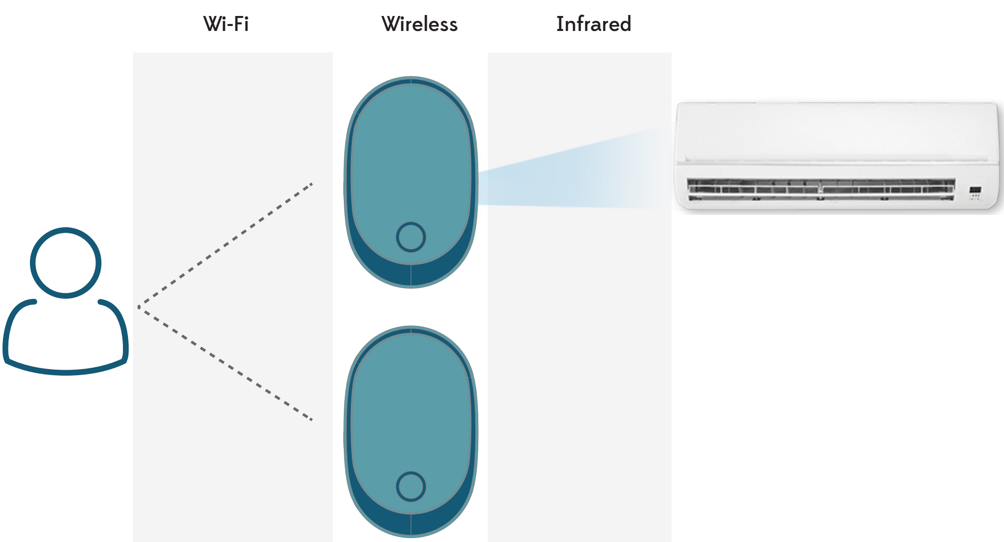


Chart 3.1: Product Connection

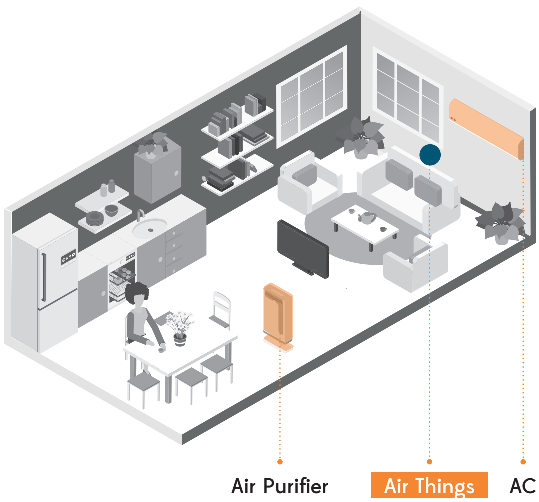
Chart 3.2 Product Configuration

Stando alone, Macro Area

One of the critical points of the dispositions present in commerce concerns the limitation in collecting the data in a limited space from the room in which it is located.
The Air Things device was designed to have a different scalability. The solution is based on the physical distance between the devices for which we will have a Stand Alone mode and one in Macro Area. Thanks to this configuration there is no limit to the extent of the monitoring area.

STAND ALONE

Given the strong presence of increasingly large spaces that share pollution, a stand-alone mode has been designed which consists of an isolated device that does not need to interface with the chain. It is designed to detect the parameters of a single environment and consequently act according to its possibilities.



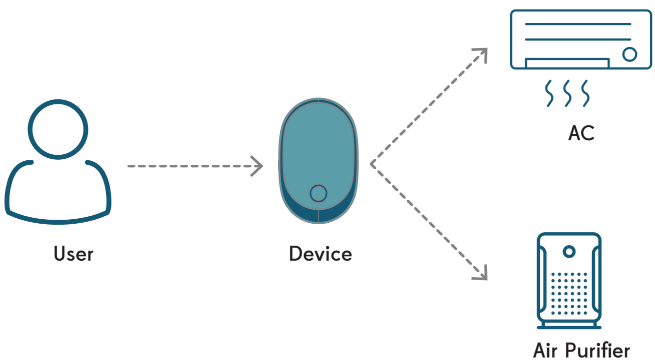
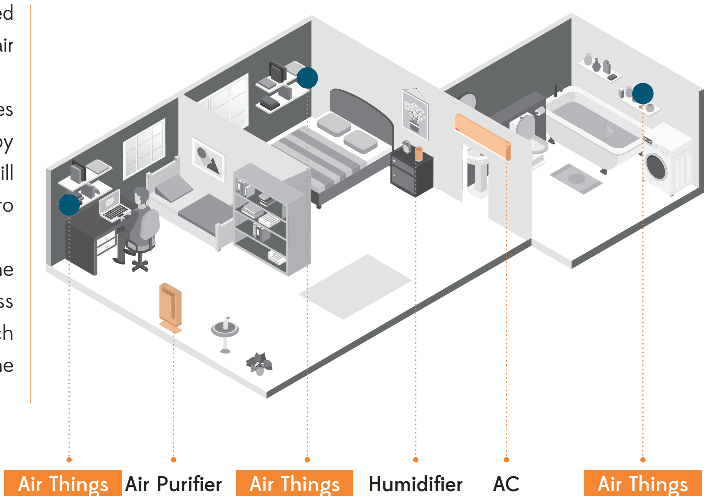


Chart 3.3: Stand Alone Configuration

Chart 3.3: Stand Alone Configuratio

MACRO AREA

The Macro Areas system is designed for environments with the same air treatment.
Being a system needs devices to interact with each other by exchanging data / info. They will establish a connection (bridge) to obtain the best environment.
Through this configuration the devices create a bond of closeness between them thanks to which allows them to be able to share the devices with each other.



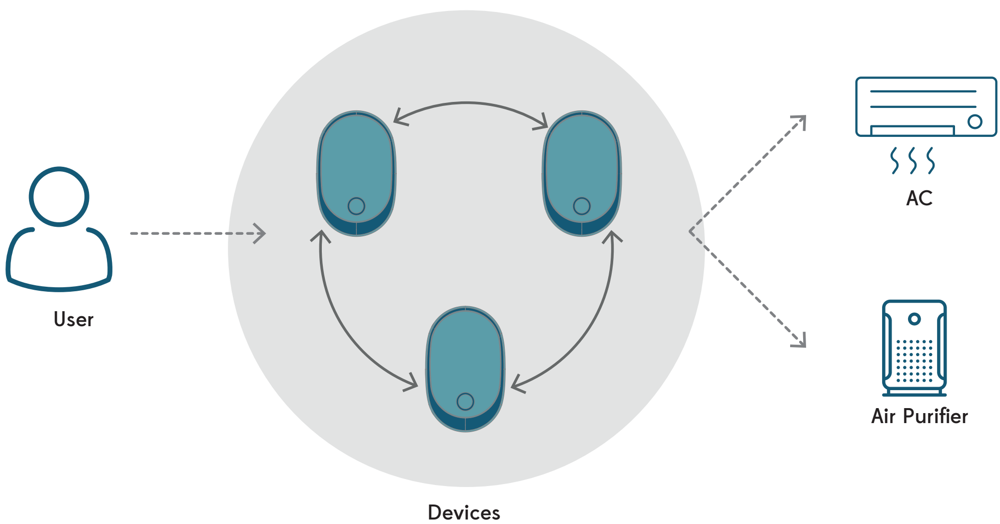


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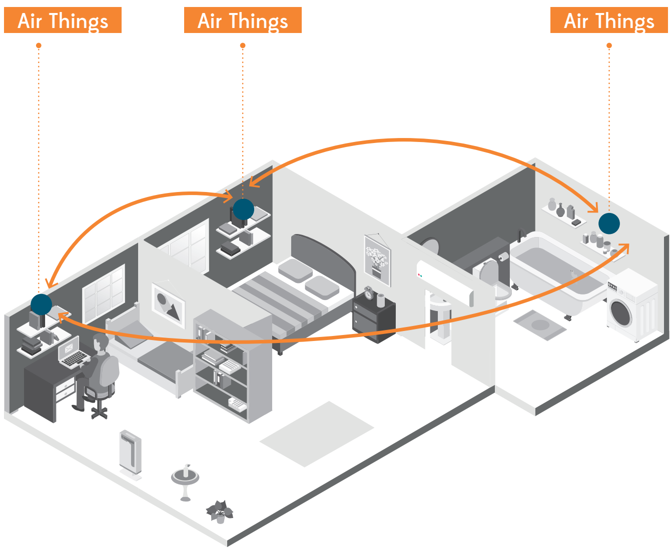
Chart 3.4: Macro Area Configuration

HOW TO CREATE A LINK

One of the key aspects that differentiates Air Things from other products is the ability to exchange information with other devices in order to create an alway on experience.
To do this they used the wi-fi connection supplied with the Raspberry. They will exchange data by sharing, as devices creating a share of them.

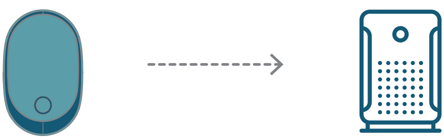
One of the problems encountered is how to actually create a link between them. During the on-boarding phase, through the App provided, the user will be asked first of all to create a link between Air Things and any devices for air treatment; then it will be asked if, according to him, there is a physical proximity between different devices even in different rooms.

As this is a crucial step, it is not possible to leave it only to the free interpretation of the user. Using the Machine Learning principle, the system is able to understand if an event that is recorded in a room has repercussions even in another room where the device is present.
Thanks to this model, the system is able to learn and independently establish a link between the devices, managing to determine which device is best activated in all circumstances



01

I create links between Air Things and any home appliace



02

A link is established between the different Air Things

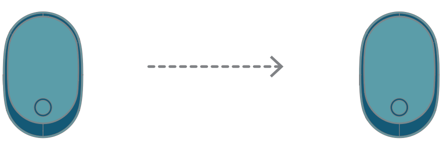


Chart 3.5: Link Creation

The interface

The interface is one of the strengths for which this product differs from its competitors on the market.
Analyzing the various competitors, it can be seen that almost all of them position the interface located on the front of the product, a layout that is not very suitable for easy reading and interpretation of data by the user, or worse still does not communicate any information preferring a software type interface.
The goal was to be able to communicate only really sensitive data and that the user is able to interpret.

The choice of the data that the user can really understand and interpret is provided by two levels of communication, that is through a backlit screen, one is able to have more detailed information on the air trend, and a comprehensible communication on a universal level through the use of LEDs.

It was considered appropriate to arrange the interface using the product configuration. In the front part the backlit display has been positioned for a better view and reading from above, while the data reading button has been necessary to provide a high importance placing it in the central part, area more accessible to the user's hand. Two buttons of secondary importance have been positioned laterally, allowing them to select the different operating modes.
The product was developed with **three interface levels,** and they are: LED, LCD display, App.

01

LED

The interface consists of LED components placed inside the product. The addition of a light component is designed to make interpretation even easier.

LED Blue
Cleaning phase in progress

LED Oragne
State of alert - something is wrong

Figure 3.6: LED interface

02

LCD

The LCD screen will communicate to the user the air quality, using a value recognized as the air quality index, while the LEDs have been integrated to indicate the status of the product, if it is in operation we will have a white color, if they want to warn any state of alert will be indicated with a red color.

The use of the display allows a clear reduction of the permanent icons and symbols of the product, an advantage that translates into a clear and intuitive interface. From the analysis of use and from the interviews carried out, a problem emerged was precisely, the overabundance of interface input. As you can see from the images, the only icons on the product are those to select the function mode and the button to access internal information.

All other information will instead be readable on the display.

Figure 3.7: LCD interface

03

APP

The app was created to be able to analyze every value that is detected.
It allows you to monitor every single room where Air Things has been installed.
The app has been developed to give an overview of the different rooms in order to have control over each one.
The user is then able to select the desired room to view the statistics in real time.
In order to communicate, we have chosen to use a very simple language that can be easily interpreted.
The section dedicated to statistics allows to analyze the trend in the short and long term, in order to observe the trend of pollutants.

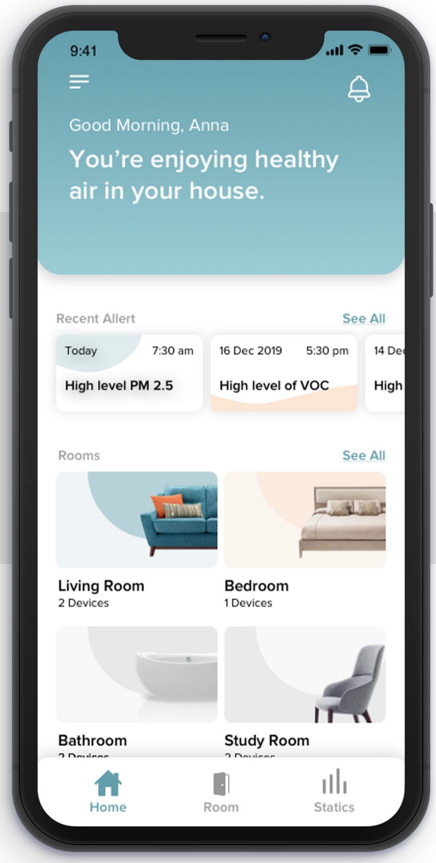
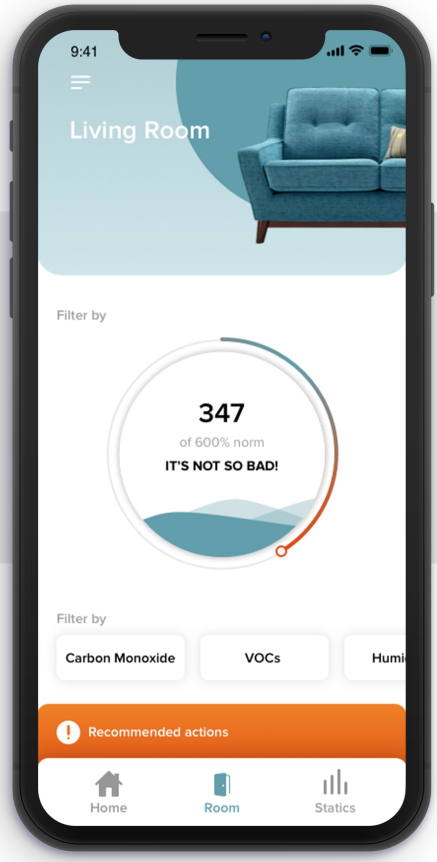
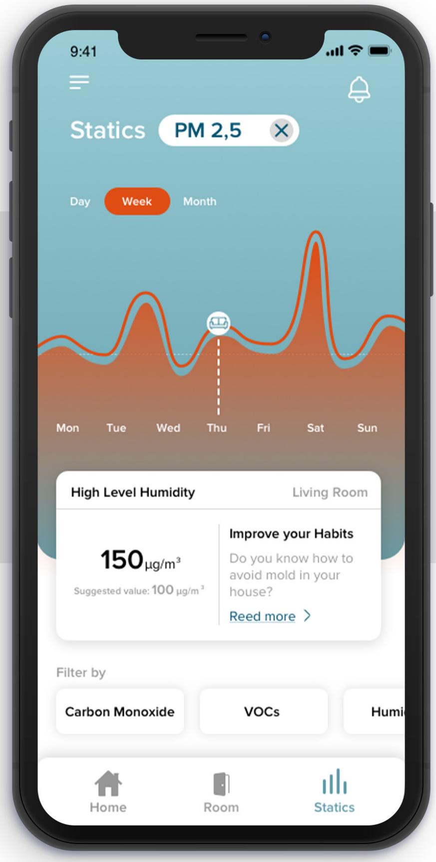


Figure 3.8: APP interface


9:41
Living Room
Filter by
347
of 600% norm
IT'S NOT SO BAD!
Filter by
Carbon Monoxide
VOCs
Recommended actions
Home
Room
Statics


9:41
Statics
PM 2,5
Day
Week
Month
Mon
Tue
Wed
Thu
Fri
Sat
Sun
High Level Humidity
Living Room
150 μg/m³
Suggested value: 100 μg/m³
Improve your Habits
Do you know how to avoid mold in your house?
Reed more
Filter by
Carbon Monoxide
VOCs
Home
Room
Statics

The interaction

The product does not want to exercise the user to learn new types of interaction, on the contrary it seeks to make the best use of the existing ones to communicate which function activates a certain pressure on the product.
I have tried to clean up the product from useless interaction models, making the most of the technology already established on the market and the actions that the user is used to making; the interaction models are fundamentally 2.
The use of a strong impact component such as the central button, imposes on him a considerable importance, for this as a response to his pressure the backlit screen is activated, which alternatively would remain in stand-by mode.

To impose second level importance on the mode selection buttons, they have been placed next to them. However they communicate the essential, and are easily accessible to the user. Upon pressing, the activation of the selected function will be displayed by means of a LED indicator located on the front of the product.

Figure 3.9: Interaction User Device

Principle of Function

Storyboard

This paragraph wants to explain the functioning of the whole system that has been designed and not of the single parts, highlighting those that are aspects of usability of the project. In particular, a storyboard will be developed to visualize the main steps of using the project, focusing on some aspects.
To better understand the potential of the product it is correct to analyze it not only on a single day but, to have a global vision and how it can improve people's habits, the trend over a given period of time.
The product, which is described as a silent overseer, comes into operation only after detecting an excess of a pollutant. Thanks to its two different ways of use, it will be explained which potential scenarios could be.

In order to better understand the evolution and behavior of the product, the storyboard was organized based on a user's potential day and how it interacts with Air Things.
For the use of the product 3 phases are necessary, the first one of configuration, then of use and finally of the possibility of evolution of the product.

PHASE 1: ON-BOARDING

1.

Association between Air Things with an air treatment device, by pressing the button and pressing the remote control. Using the infrared frequency I create a communication channel

2.

I create a link between them, going to configure the peer-to-peer model.

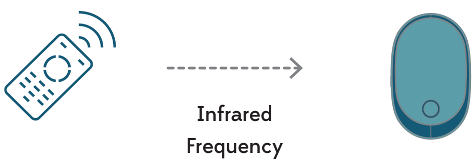


Figure 3.10: Product Configuration

Chart 3.6: on-boarding phase

USAGE

h: 14

Cleaning the house: someone is using cleanser or bleach to clean the floors, which releases load of chemic compound (VOCs) when the floor dries. A spike in tiny particulates (PM2.5) is common during cleaning sessions and usually occurs while vacuuming or moving objects around.

The product, positioned in a strategic area of the bathroom, identifies a potential state of alert, due to an excess of VOCs.
It is able to elaborate the best solution communicating with the Air Things network and consequently provides to turn on the air purifier in the corridor.

Autonomous (Macro Area)

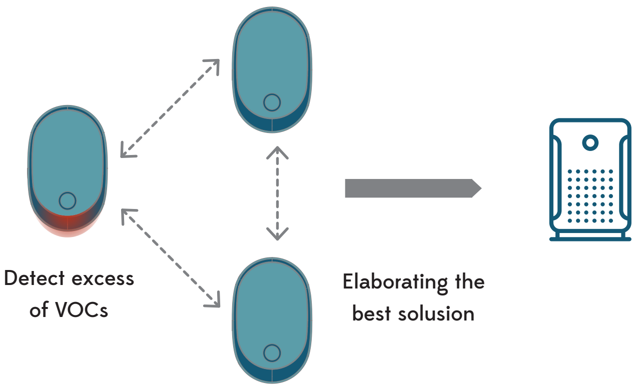


Chart 3.7: Autonomous example

h: 16

Kid come back home: School is out, and kid race through the house in excitement. She is trying the new paint but it is full of VOCs.

The mother, by pressing the button on the side, decides to set the device on the Eco function and when an alert status is detected, she is notified by a light signal on the device and by a notification on the dedicated APP.

Modalità Eco

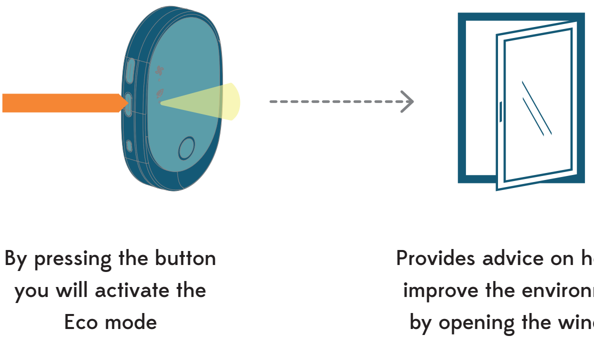
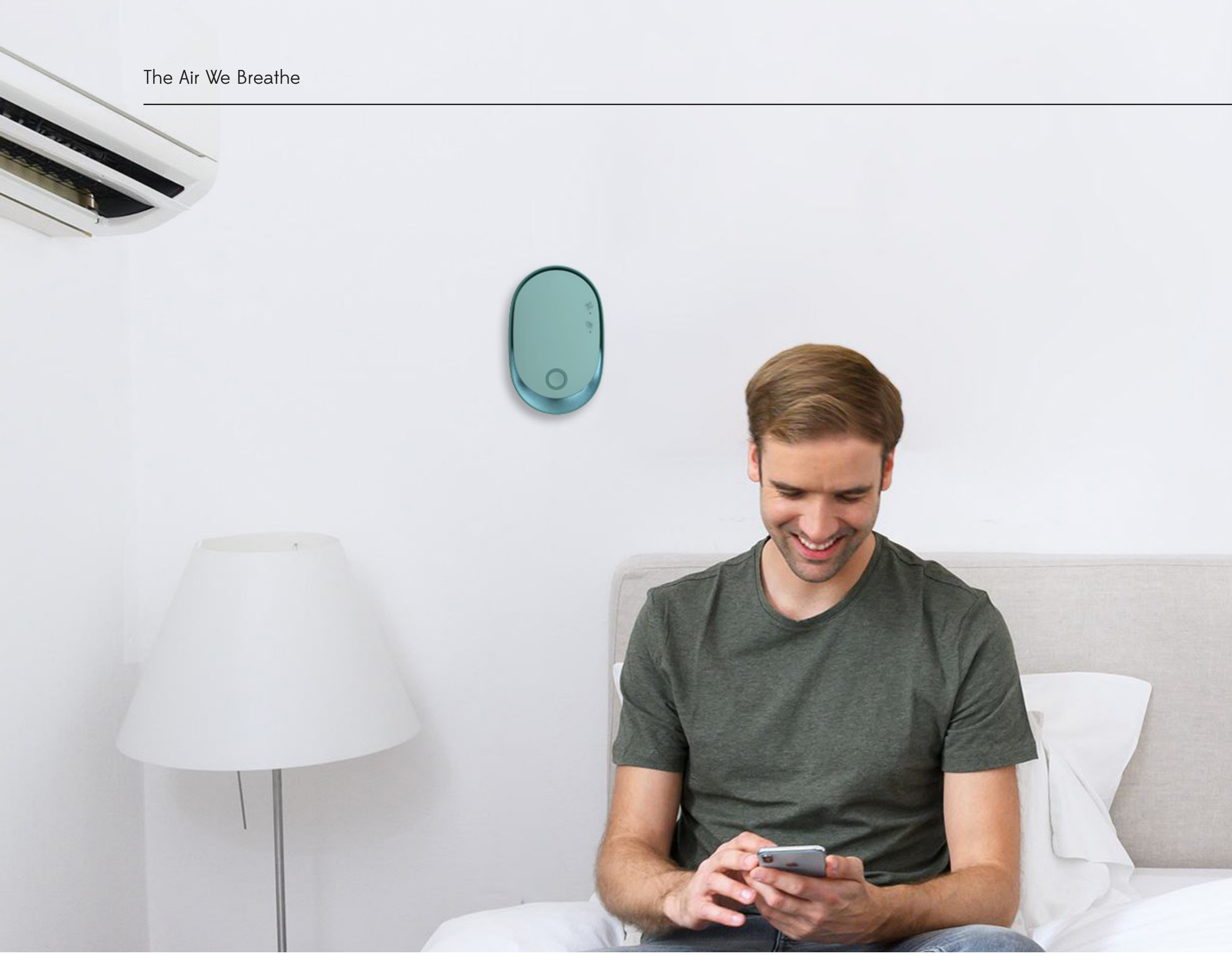


Figure 3.11: Product Alert State

Chart 3.8: Eco Mode



h: 19

Cooking: even a convivial moment like cooking and then having dinner together can be a source of pollutants that are harmful to health.

Air Things, installed in the kitchen and isolated from any other device, directly activates the suction system present in the kitchen.

Autonomous (Stand Alone)

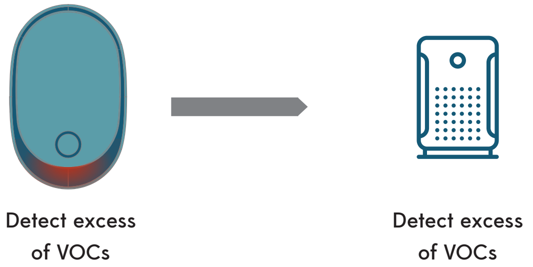


Chart 3.9: Automous mode in stand alone environment

h: 22

Goodnight: through the use of the app the user can check the progress of the pollutants throughout the day. Information is provided on which area is the most polluted and which pollutant. Thanks to this, new feedback is suggested on how to improve one's habits.

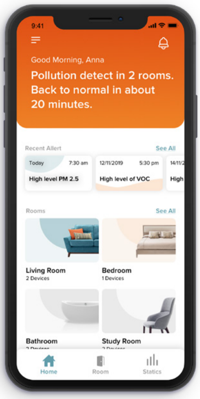


Figure 3.12: App Exploration

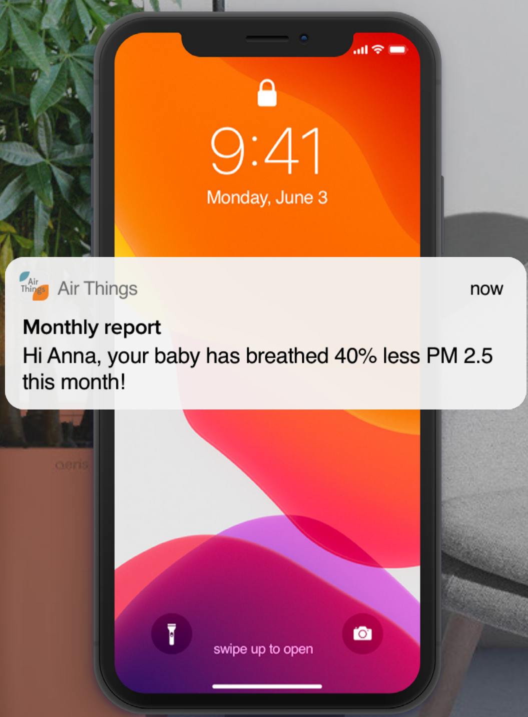
Figure 3.13: App Alert a

TEACHING

1 month later

The system identifies the areas most affected by pollutants and provides solutions to users.

Thanks to suggestions based on user activity one month later, the user is notified of pollutant trends. (the mother is notified that her children breathe 40% less polluted air) this happens thanks to the improvement of the lifestyle, in the bathroom a plant has been added that helps to reduce humidity, the children only play with paints without VOC.
Following a reading of how the air treatment devices affect the quality of the air, Air Things is able to process and therefore suggest the replacement of filters in the AC.



Different Scenarios

The use of Air Things was one of the key points around which the entire research phase and the design were based.
The intent was to create a very practical product that could be adapted as much as possible to the domestic context. However, it is precisely our homes that present numerous variables that can compromise the malfunctioning of the device. They can be classified as environment, technological or human in nature.

The environmental variables are all those actions that create a barrier or a new entry of air into the house. They can be represented by the opening or closing of doors and windows. The eventuality that a door prevents the flow of air from one room to another could alter the peer-to-peer system, so the system is able to understand if the action it has activated is able to improve the environment, otherwise it stops working.

Technology does not always benefit the product. Relying on air cleaning devices built by third parties implies a very limited knowledge of the components and cleaning capabilities.
In extreme cases where the user has no device to be able to connect to use the technology, it is limited to the device itself.

The biggest variable is certainly represented by the behavior in indoor environments of potential users. Every single action has repercussions on the quality of the indoor air, risking to make the product a continuous alert.

After having mapped the variables that can influence it was fundamental to be able to understand and analyze the possible scenarios that characterize the product.
The possible scenarios are represented by the two subdivisions listed above, ie Macro-area and stand-alone.

Figure 3.14: Product configuration anter 1 month

Component description

Made Components

The main body consists of three shells, in which the internal components, described below, are located.
Air Things belongs to the family of air monitors, although today there are no shapes on the market that characterize their appearance, their lane are very simple, probably because want to adapt to the home environment. The product is configured with a lower supporting shell, it allawos to be hooked to the wall, a front body that acts as a casing for the sensors, and the most external component that characterizes the product, going to create a contrast between it and the body. The goal was to create in the user a feeling that the air was sucked inside the gap between the two shells,

The dimensions of Air Things refer to those of existing air monitors. The main constraint, which requires its sizing, is represented by the dimensions of the air sensors.
The colors chosen for the body are deliberately neutral. White and gray, the goal was to be able to integrate the device into the home.

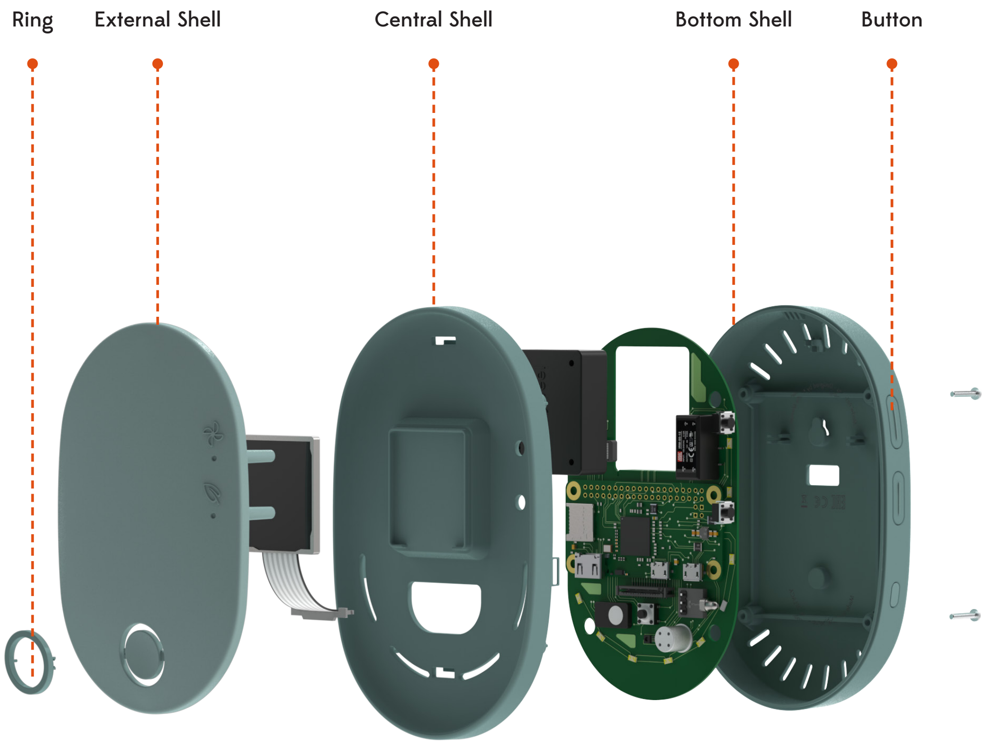


Figure 3.15: Exploded View

LOWER SHELL:

The lower body forms the basis on which the product is developed. The shape is not characterized by structural constraints, it is preferred to keep the clean, soft shape that distinguishes this product; they are hidden behind the special recess. The slight recess has been designed to guarantee regular air circulation. Also on the back there are special joints to facilitate hooking to the wall.

Figure 3.16: Lower Shell

CENTRAL SHELL:

This component is used as a connecting element between the lower body and the outer shell. It was designed with the aim of creating the illusion that the air passes inside.
The structural constraints are placed in the central area of the component, so that they can be hidden by the outer shell.
It is the most complex part, which has devoted the worst attention; it is characterized by a hole that allows the connection between LCD and PCB, snap-fit for the connection of the bodies and housing of the screws.

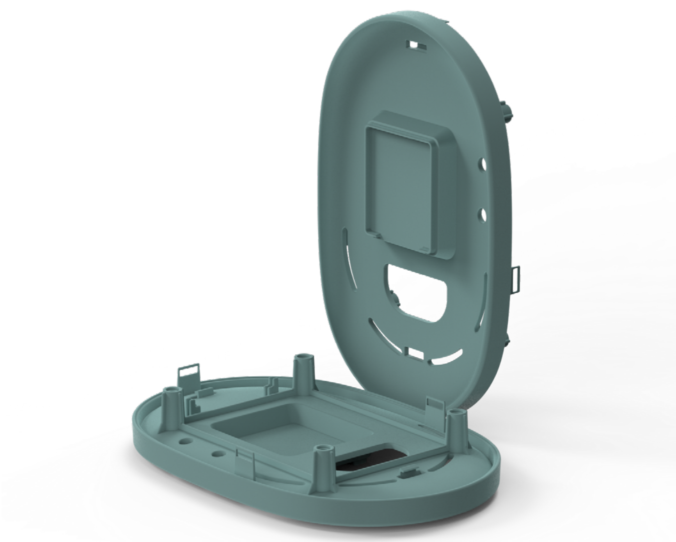


Figure 3.17: Central Shell

UPPER SHELL:

The upper body is the representative element of this product.
The shape, which wants to recall a slot, stands out from the strong trend of technological products with very definite and precise shapes.
It has a soft surface, which wants to invite the user to interact with it.
The LCD screen is hidden by this component.

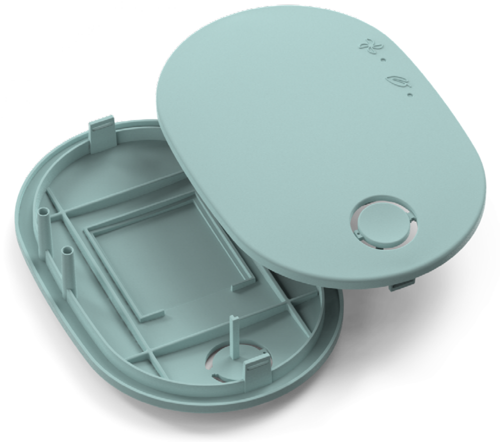


Figure 3.18: Upper Shell

WALL HOOK:

The decision to develop the product vertically and very low was the result of the research phase. This form specifically implies that Air Things must be attached to the wall and at face height, the area where most pollutants are concentrated.
To do this, a wall hook was designed. The goal was to reduce the number of holes to be made by preferring an easy hook-up and release between the body and the coupling.

Figure 3.19: Wall Hook

Buy Components

The research and the evaluation of these components involved most of the design process, and was the starting point to reach the goals set during the briefing phase. In accordance with this, these components were selected, not based on cost limits, but according to performance criteria that guaranteed the product a long useful life and the minimum need for maintenance.

The choice of sensors was influenced by three fundamental factors:
◦ Dimensions: the dimensions of the sensor are critical especially if the fi nal device must be portable. There is a wide choice on the market of ready-to-use acquisition instruments, capable of monitoring the concentration of a particular chemical species, but which, if combined to form a more complex monitoring system, would be excessively bulky and therefore difficult to transport .
◦ Measurement range: the sensors chosen must be able to provide accurate measurements
◦ Cost: among the sensors that meet the previous requirements, those with lower (retail) prices have been chosen. This last discriminating factor was applied not only in the choice of sensors, but also for all the other electronic components that will constitute the measurement system. In this way the fi nal device will cost as low as possible and therefore is the perfect candidate for clinical exposure studies characterized by a large number of recruited subjects.

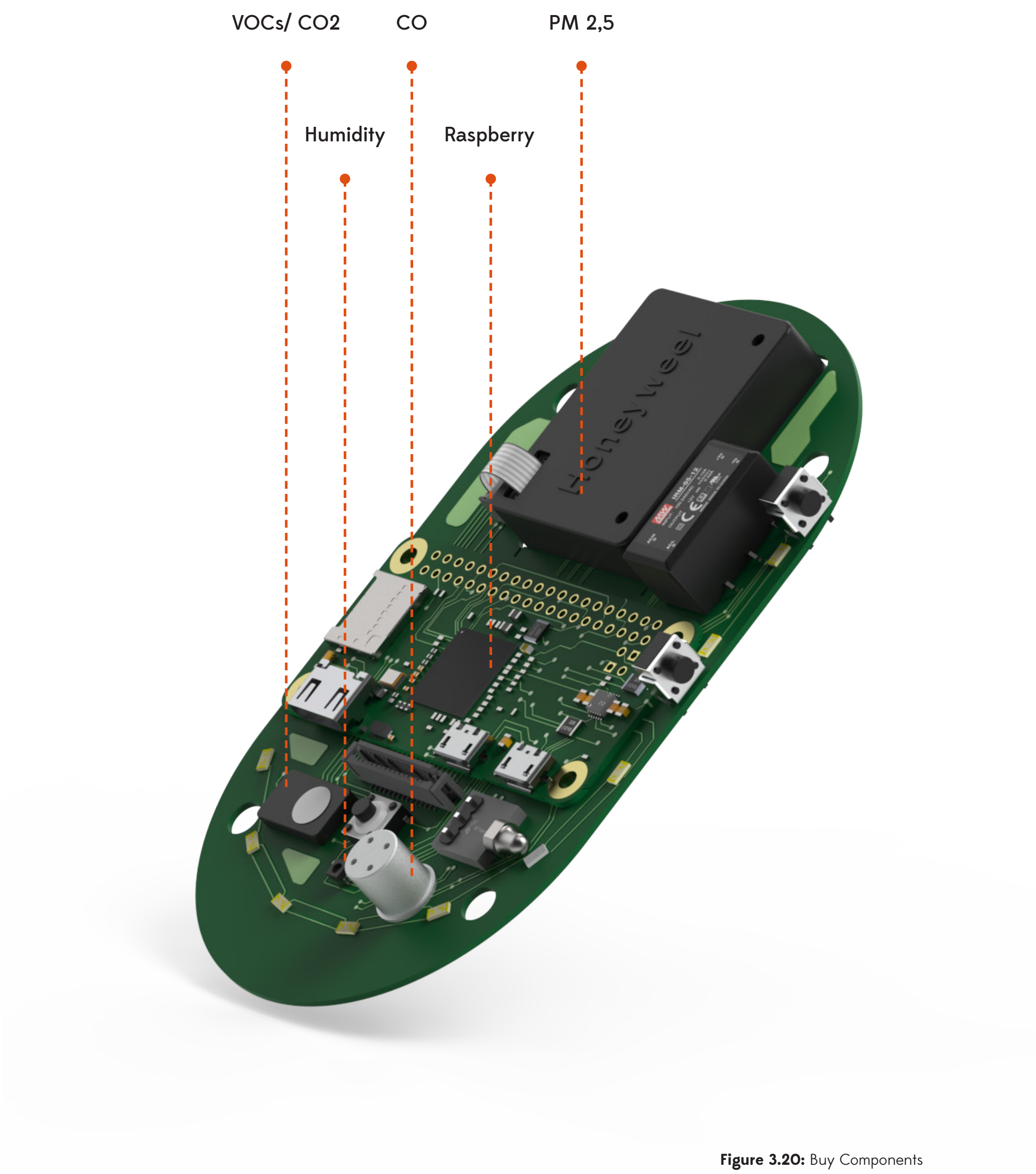


Figure 3.20: Buy Components

PCB

It is a resin board on which the elements are placed to detect, receive, process and send all the information.
It has the maximum dimensions of 120x70x2mm. The electronic card has a slot shape on which all the modules are placed.
The power button is located in the upper part of the card: simply press it to activate all the parts of the card. When the power is turned on, the front LCD screen lights up. Two side buttons are also mounted to select the mode of use.

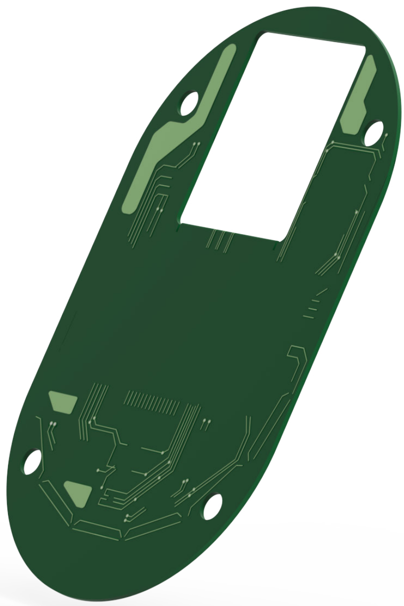


Figure 3.21: PCB Component

RASPBERRY PI ZERO

The control unit of the portable device is the Raspberry Pi Zero. The Raspberry Pi Zero is a small, complete, and breadboard-friendly board based on the ATmega328P.
The ATmega328P is a low-power CMOS 8-bit microcontroller, a flash memory of 32 kB (with 2 kB used for the bootloader), a SRAM of 2 kB and a EEPROM of 1 kB.
The Raspberry Pi Zero can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin VIN), or 5V regulated external power supply (pin 5V). The power source is automatically selected to the highest voltage source.

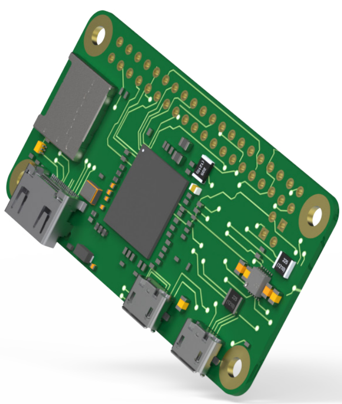


Figure 3.22: Raspberry PI Zero

INFRARED, HC-SR501

Infrared technology allows wireless connections between electronic communications and computing devices. The technology is based on a radio link that offers fast and reliable data transmissions.
The infrared module chosen is HC-SR501. It is a preassembled module specifically for installation on the PCB. To prevent the 38KHz frequency from being disturbed by the lower shell, an HD-PE slot has been designed, typically used in remote controls, which allows it to be transmitted.

Name: HC-SR501
Dimension: 15 X 10 mm
Consumption: 60 mA
Voltage: 5V
Price: 0,4€

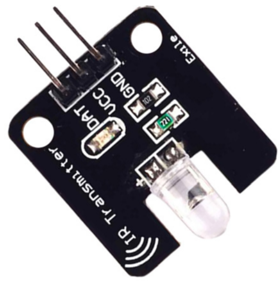


Figure 3.23: Infrared HC-SR501

LCD

The NMLCD-220Q33 is color active matrix liquid crystal display with light emission diode(LED) backlight system. The matrix employs a-Si Thin Film Transistor as the active element.
It is transflective type display operating in the normally white mode. This TFT-LCD has 2.2 inch diagonally measured active display area with (320*RGB*320) resolution. Each pixel is divded into red, Green and Blue sub-pixels or dots which are arranged in vertical stripes.

Name: NMLCD-220Q33
Dimension: 30 X 30 mm
Consumption: 50 mA
Voltage: 2.7V to 3.6 V
Price:: 2€

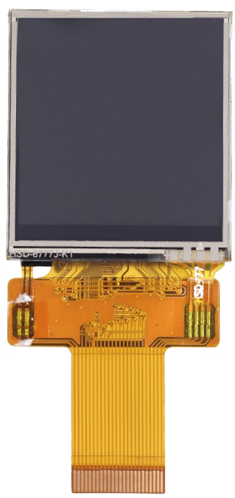


Figure 3.24: LCD NMLCD-220Q33

HUMIDITY, DHT11

The temperature and humidity sensor used is the DHT11 sensor mounted on a small PCB.
DHT11 digital temperature and humidity sensor is a calibrated digital signal output of the temperature and humidity combined sensor with a resolution of 16 bits. It uses a dedicated digital module capture technology and the temperature and humidity sensor technology to ensure that products with high reliability and excellent long-term stability. Sensor includes a resistive element and a sense of wet NTC temperature measurement devices.

Name: SHT3x-DIS
Dimension: 2,5 X 2,5 X 1 mm
Reliability: High
Voltage: 2.1 V to 5.5 V
Consumption: 0,6 mA
Output: I2C
Price: 1,5 €

Figure 3.25: Humidity, DHT11

PARTICULATE MATTER 2.5, HPM 32322550

To detect the particulate matter 2.5 (PM2.5) concentration, the HPM Series 32322550 sensor is chosen. It is an optical dust sensor that is designed to sense dust particles. An infrared emitting diode and a phototransistor are diagonally arranged into this device, to allow it to detect the reflected light of dust in air. The dust passes in the sensor through a hole. It is especially effective in detecting fine particles larger than 0.8μm in diameter. The sensor can measure dust density up to 0.5mg/m3.

Name: HPM 32322550
Dimension: 44 X 36 X 12 mm
Reliability: Medium - High
Voltage: 5V
Consumption: 60 mA
Output: I2C
Price: 4€

Figure 3.26: PM HPM 34322550

CARBON DIOXIDE, VOCs IAQ-CORE

The iAQ-Core sensor module is used to measure VOC levels and provide CO2 equivalent and TVOC equivalent predictions. The sensor module can be soldered directly to a host circuit board with selective or reflow soldering via the edge connectors.
Unlike other sensors on the market, which only detect one parameter, this module is able to measure two fundamental parameters such as CO2 and VOCs, so as to reduce the cost and space occupied by two sensors.

Name: IAQ-CORE C
Dimension: 18 X 11 m mm
Reliability: Medium-High
Voltage: 3.3 V
Consumption: 20 mA
Output: I2C
Price: 8€

Figure 3.27: Carbon Dioxide, VOCs, IAQ-Core

CARBON MONOXIDE, TGS2600

The carbon monoxide (CO) sensor implemented in the system is the TGS2600 sensor mounted on a PCB. This CO gas sensor detects the concentrations of CO in the air and outputs its reading as an analog voltage. The sensor can measure concentrations up to 2000 ppm (parts per million).

Name: TGS 2600
Dimension: 9X 7 X 10 mm
Reliability: Medium
Voltage: 5V
Consumption: 42 mA
Output: I2C
Price: 6€

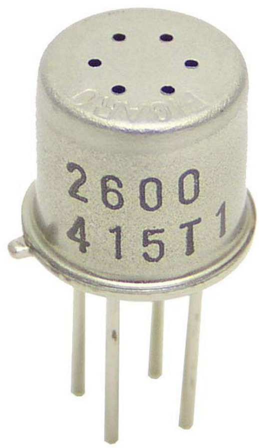


Figure 3.28: Carbon Monoxide, TGS2600

Engineering

Material Selection

After a careful research on the materials that are currently used in this family of products I have identified, for the main components produced, the material class of belonging.
A first phase was formed to identify the constraints in the selection of materials, they were transformed into design requirements and, through the use of CES Ashby software, it was possible to obtain a first Material selection.
The Next step was the one to deepen the research and taking into consideration such Processability, Costs, and Design Requirements, in order to identify the appropriate material.

GENERAL REQUIREMENT:

The main aim is that the product will have an excellent surface finish.
The construction material must satisfy the following principles:
_ High level of cleanability and surface finish
_ Good Resistance
_ Resistant to abrasion
_ High surface finish
_ Easy to clean

Three elements of families with different needs have been identified and are: the first lower body, rear, I eat on the wall and buttons; the second is composed of the upper body and the third by the infrared button.

LOWER AND CENTRAL SHELL:

The Requirement:

For this product the covers characterize the design, which means that it needs a specific production method.
The injection moulding allows obtaining shapes and finishes that meet our requirements. Generally, plastic polymer family is well suited to these requirements.
For some plastics, contact with water does not affect mechanical and long-lasting capacity. They are easily producible and have a relatively low material cost.
The selected materials will not have to alter the reading of the data, therefore the possible emissions will be taken into consideration following production.

Functional Constraint: Resistance to water and acids , Strength Enough, Price,
Aesthetic Costrain: High level of finish
Structural Costrain:
Free Variable: Material

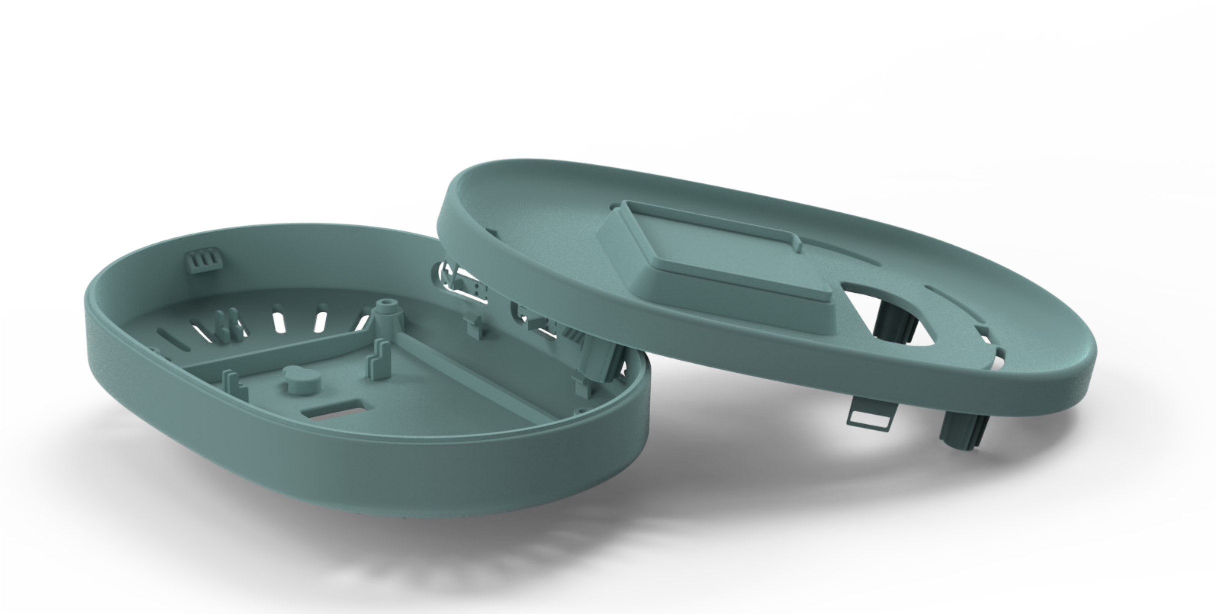


Figure 3.29: Lower and Central Shell Material Selection

Ces Requirement:
After identifying the requirements for the recognition of the material, it was necessary to introduce these parameters into the CES Ashby software and try to merge them.
The parameters required for the search for marriage are mainly mechanical. The goal was to identify a material with fair properties that is easily available on the market.

Requirements:
Young's Modulus,
Price,
Water Resistant,
Organic Solvent Resistan
Good resistance to UV rays and atmospheric agents
Polymer injection molding

RESULT:

After the result it's needed a material comparison to choose the lightest and cheapest material.
From this graphascertain that Polypropylene represents the best solution, since it has a low density, low price and a medium Young's modulus. This result is confirmed by the fact that almost all the components for the cleaning room are made by this material.

MATERIAL	ABS
PRICE	1,93 - 2,02 EUR/kg
DENSITY	$1.01e^3$ - $1.21e^3$ kg/m^3
YOUNG'S MODULUS	1.29 - 2.9 GPa
YIELD STRENGHT	46 MPa
POISSON'S RATIO	0,46 - 0,55

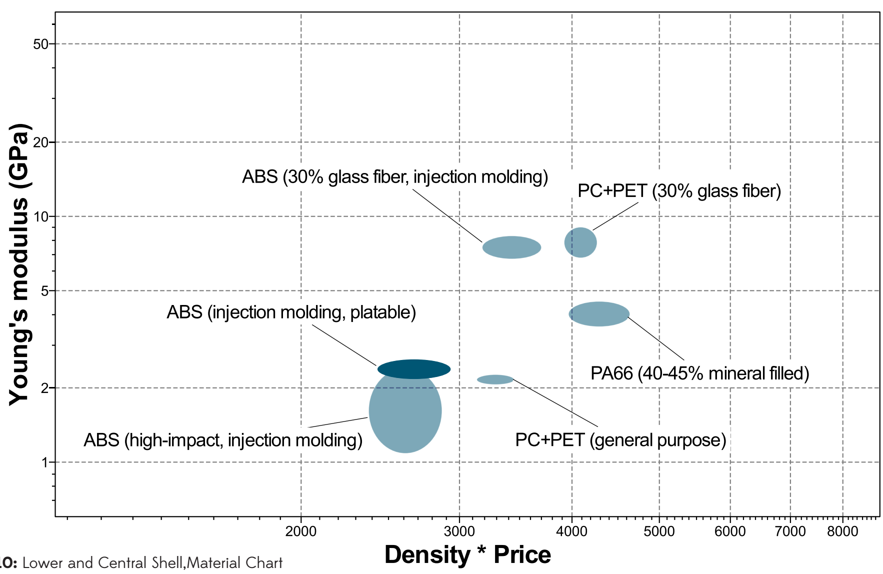


Chart 3.10: Lower and Central Shell,Material Chart

UPPER SHELL:

The Requirement:

The upper Shell is the element that will come into contact with users, which is why the choice of material is conditioned by frequent use and how cleaning agents can change its appearance.
In order to create the effect of a backlit screen, the upper shell, unlike the components previously described, must have an almost transparent opacity.

Functional Constraint: Resistance to water and acids , Strength Enough, Price,
Aesthetic Costrain: High level of finish, Semitransparent
Structural Costrain:
Free Variable: Material

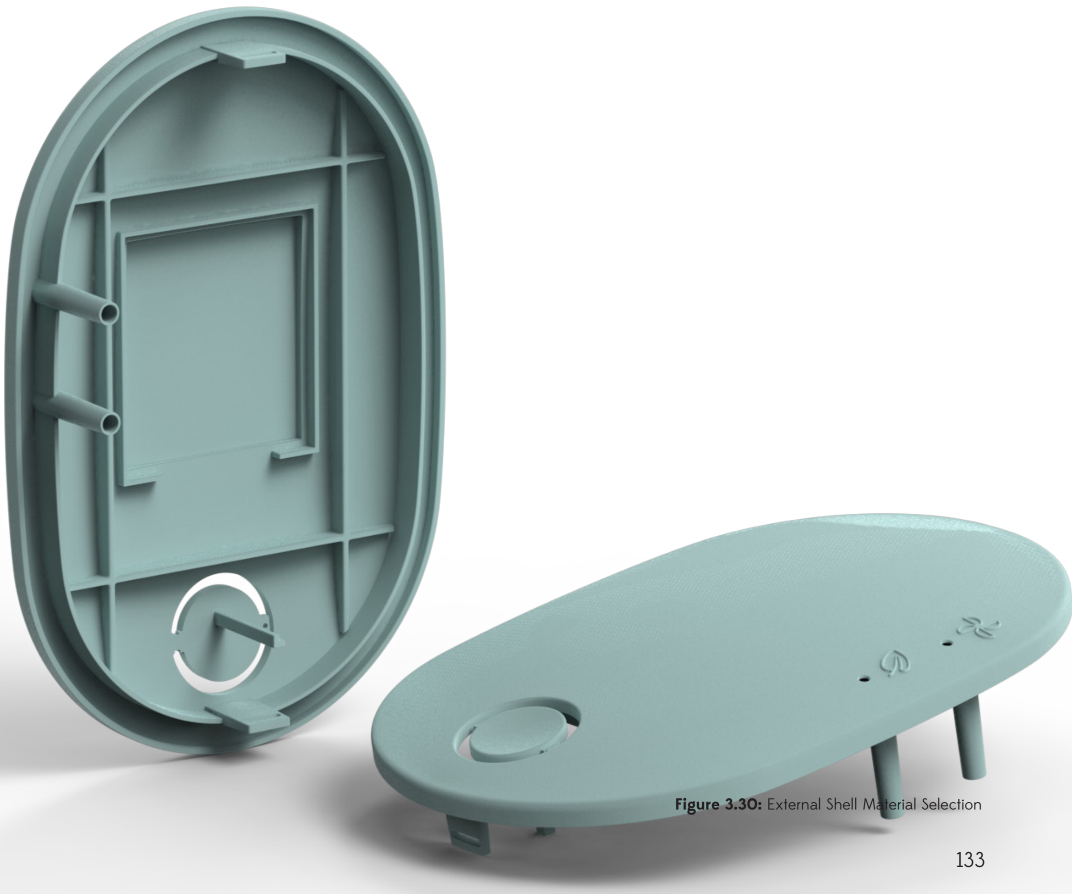


Figure 3.30: External Shell Material Selection

Ces Requirement:
After identifying the requirements for the recognition of the material, it was necessary to introduce these parameters into the CES Ashby software and try to merge them.
The selected material must be able to be injected molded and able to resistant to acids and water.

Requirements:
Young's Modulus,
Price,
Water Resistant,
Organic Solvent Resistan
Good resistance to UV rays and atmospheric agents
Polymer injection molding

RESULT:

The decision is to choose High density polyethylene, PC because this material not only presents advantages for its density and its price, but as the limits shown, it is suitable to support the forces that are applied.

MATERIAL	PC
PRICE	1,45 - 1,51 EUR/kg
DENSITY	7,8 e^3 - 7,9 e^3 kg/m^3
YOUNG'S MODULUS	1,01 - 1,03 GPa
YIELD STRENGHT	29,8 - 31 MPa
POISSON'S RATIO	0,41 - 0,42

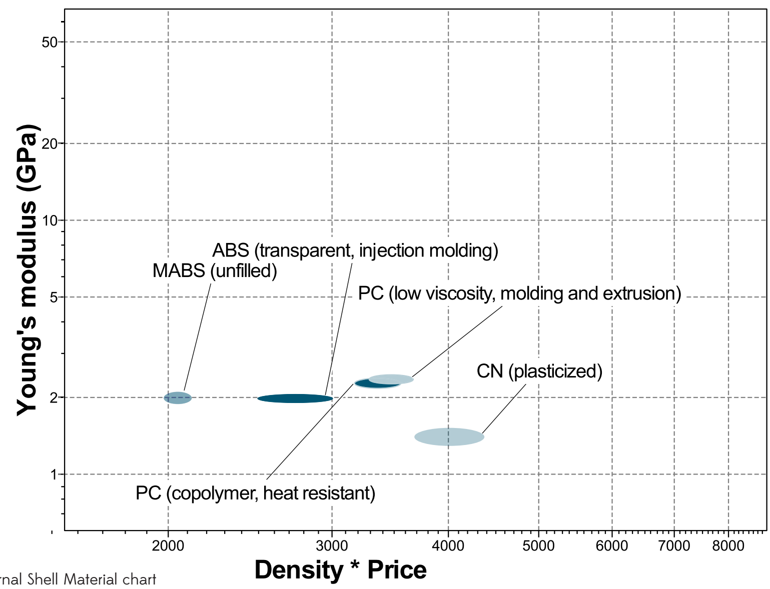


Chart 3.11: External Shell Material chart

INFRARED BUTTON:

The Requirement:

Once the main components that characterize the product have been defined, the secondary elements have been defined but not in importance. One above all the infrared slot in the lower body. It differs with the remaining products in that it must allow entry and exit of the infrared signal.

Functional Constraint: Allows the passage of Infrared
Aesthetic Costrain: Semitransparent
Structural Costrain:
Free Variable: Material

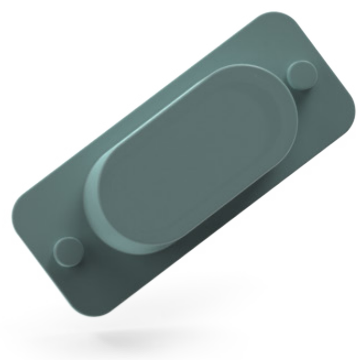


Figure 3.31: Infrared Button Material Selection

Ces Requirement:
After identifying the requirements for the recognition of the material, it was necessary to introduce these parameters into the CES Ashby software and try to merge them.
The main and exclusive constraint is the infrared transmission.

Requirements:
Refractive index,
Polymer injection molding

RESULT:

From this graph we can notice that PE_HD seem to be the best materials in terms of Elastic Limit and Price.

MATERIAL	PE-HD
PRICE	1,33 - 1,47 EUR/kg
DENSITY	952 - 965kg/m^3
YOUNG'S MODULUS	1,07 - 1,07 GPa
YIELD STRENGHT	26,2 - 31,1 MPa
POISSON'S RATIO	0,41 - 0,427

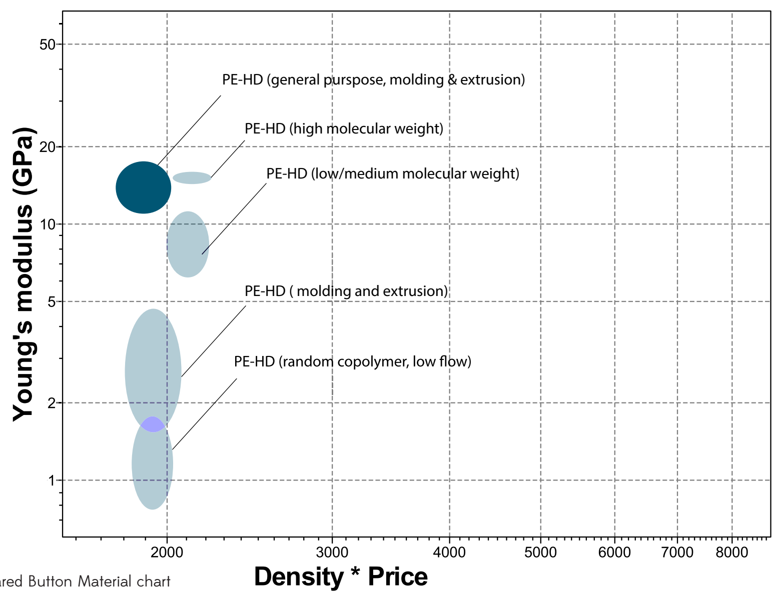


Chart 3.12: Infrared Button Material chart

Manufacturing Processes

In design phase it is essential to suggest process and assembly steps for this proposal. Considering BOM, geometrical & material constraints reasonable methods suggested below. For each critical make-part applied design rules listed.

The air monitors business is still very young, we are in a situation where there is no real market segment and moreover the companies that are entering this sector are mostly start-ups. Users are only beginning to consider domestic pollution as harmful to their health during this period; these factors allow us to consider the market open to new solutions with the possibility of reaching a high level.

Nowadays there are more han 12 million of different house in Italy. For reasonable and justified selection, It has been assumed that %1 of the market can be good starting point for the sector.

The geometrical constraints, material and the annual batch sizes investigated together to make reasonable and strong hypothesis.

Considering the market need and industries, annual batch size assigned to 120.000 which refers to “medium to high” production.

Taking as a reference the FIRST table (ANNEX N.), which is responsible for identifying what type of manufacturing process is suited to batch size, is referred to as the injection molding can best meet the design requirements.

Below we will analyze what are considered the components with critical aspects of production.

INVESTIGATED CRITICAL MAKE-PART

The process used for the bodies is injection molding, a process that allows the mass production of plastic components with high finishing characteristics.
This choice has made it possible to limit the number of components, thus reducing assembly time, without limiting the objectives set by the brief. The main body of the bodies is formed by an injection of ABS, which optimally combines high workability, flexibility and excellent mechanical properties of impact resistance.
The outermost component is always obtained in PC injection molding that offers excellent toughness, even at low temperatures, making this material ideal for a product exposed to the most diverse climatic conditions.

Injection Molding

injection molding is a widely used and well-developed process that is excellent for rapid production of identical parts with tight tolerances. It is used to create a huge diversity of our day-to-day plastic products. Accurately engineered tools and high injection pressures are essential for achieving excellent surface finish and reproduction of detail. Consequently, this process is suitable only for high volume production run. Designing for Injection molding is a complex and demanding task. Tooling costs are very high and depend on the number of cavities and cores and the complexity of design. Injection molding can produce small parts very rapidly, especially because multi-cavity tools can be used to increase production rates dramatically.

Wall Thickness

The wall thickness should be as nearly uniform as possible to ensure more rapid molding cycles, conserve material, and avoid distortion due to cooling. The ratio of wall thickness should not exceed 2:1 and the minimum section for thermoplastics is 0.4mm.

In this part;

Body Thickness 2mm

Botton / wall Thickness 1 mm

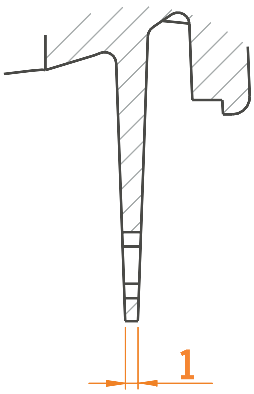


Figure 3.32: Wall Thickness

Draf Angle

The part design should permit portions of the mold that are perpendicular to the parting plane to have a draft. This is preferred to a square configuration in ensuring that the molded part can be removed from the mold. Draft angle ranging from less than 0.25 to 4, depending on section depth.

In this part;

Body draft angle: 2°

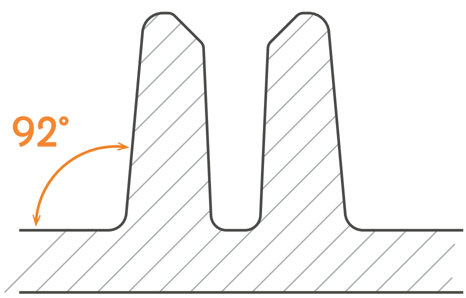


Figure 3.33: Draft Angle

Corners:
Generously rounded corners and large fillets are necessary in injection molding parts to maintain more nearly uniform wall thickness and ensure easy molding and maximum strength of the molded part, so Radius should be as generous as possible.
Minimum inside radius=0.5 times the the material thickness

In this part;
Body Thickness 2mm
Rounf Thickness 1mm

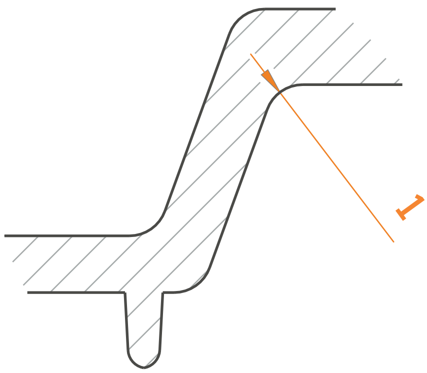


Figure 3.34: Corners Radius

Undercut
In injected molded parts there is the possibility to create undercuts. It make the mold more complex and expensive, but for create interlocking or snap are fundamentals.

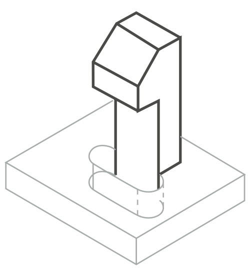
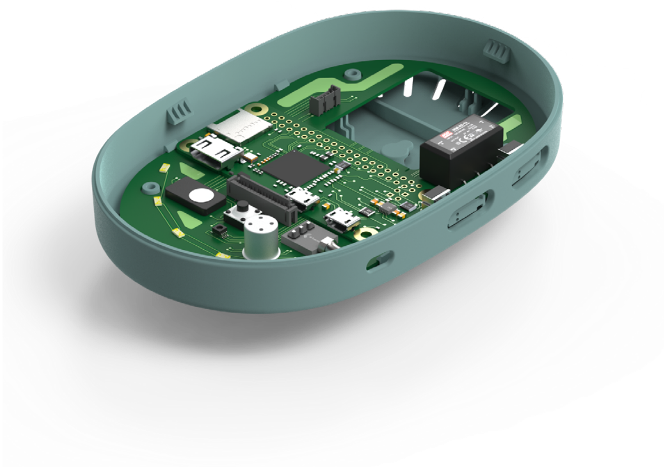


Figure 3.35: Undercut

The assembly

The assembly was taken into serious consideration during the design phase, given that this process constitutes an important fraction of manufacturing costs and therefore of the final costs of the products. In this regard I have tried to simplify the assembly as much as possible, focusing also on the arrangement of the internal tubes that communicate with the exterior, and of those that connected to the PC-Board allow the user to have suction feedback. In particular, the orientation with which the pump-motor is arranged with respect to the product, allows to see clearly and easily connect the various parts of the system. The entire assembly process will be from top to bottom starting from the front body, on which all the internal components will be placed. The parts in contact with the outside and exposed to greater wear, such as for example the leash of the patient tube or the block of the vessel, are mounted on the product from the outside. In the event that these should be replaced it will not be necessary to disassemble the body of the product and consequently request external assistance.



STEP 1: PCB

The front shell, deliberately flat on the front, rests on the work surface. The first component to be inserted is the printed circuit. On the PCB there are some rooms that allow to place the electrical component in the right position. The use of the printed snap-fit in the lower body allows the vertical movement of the component to be constrained.
This design choice allows assembling the product without the use of fixing components

Figure 3.36 to Figure 3.42 : Assembly Process

STEP 2: PM 2.5 sensor

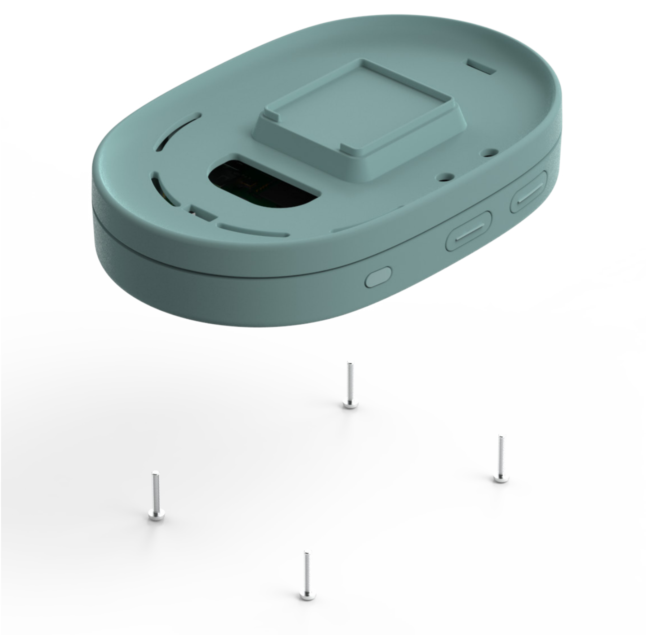
The PM 2.5 sensor is located inside the product without the use of screws and is held in place by appropriate notches in the shell.
At this point it is possible to connect the component with the PCB.

STEP 3: Button

Once the electronic components have been placed, it is possible to insert the two buttons on the side of the lower body to activate the eco mode and the autonomous mode.
On them are printed two snap-fits that place the components in the correct position

STEP 4: Central Shell

The product is now closed by the central shell, which in addition to repairing the internal components from the outside, fixes some of the parts previously inserted. The union with the front body is guaranteed primarily by three snap-fixes that fix the component in a non-definitive way, on the back of the lower body are inserted 4 screws that close the component

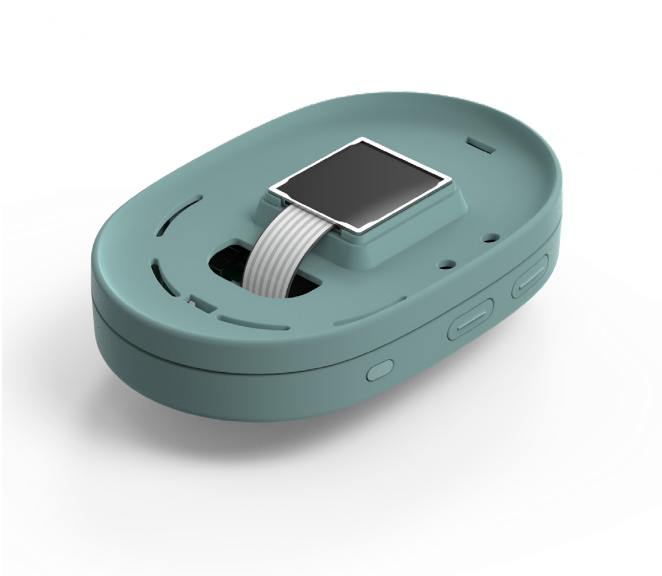


STEP 5: Screw

Once the electronic components have been placed, it is possible to insert the two buttons on the side of the lower body to activate the eco mode and the autonomous mode.
On them are printed two snap-fits that place the components in the correct position

STEP 6: LCD

The LCD screen is located in the special seat cut into the body, it is not fixed with any type of hook but serves exclusively as positioning. At this point, thanks to the specially designed slot on the rear shell, the LCD screen can be connected to the PCB.



STEP 7: Upper Shell and Ring

The last components that make up the body of the Air monitor are frontally inserted. As far as the button ring is concerned, it is pressed into the upper body.
The upper sheòò is inserted in the special notches, 3 snap fit connect with the rest of the product.

Cost Analysis

For this project Ashby Cost modelling has been done to estimate cost for shaping operations. The manufacture of a component consumes resources each of them has a cost. The final cost is the sum of those of the resources it consumes. These are consumption of material, tools, capital and overhead.
The total shaping cost per part, Cs, is the sum of these four terms, these four terms investigated for min/max and mean values and cost estimations has been calculated :

$$C_s = \frac{m\,C_m}{(1-f)} + \frac{C_t}{n}\left\{ \text{Int}\left(\frac{n}{n_t} + 0{,}51\right)\right\} + \frac{1}{\dot{n}}\left(\frac{C_c}{L t_{wo}} + \dot{C}_{oh}\right)$$

C1: MATERIAL COST

As mentioned in the material report, the Scocca inferiore has been selected as ABS. This material properties and material costs shown below. For the extrusion blow molding the fraction rates has been shown in table. The mean total cost has been estimated as per piece.

Density: 1,05 kg/m3
Material Cost: 2,35 €/kg
V= 80000 mm3
Waste= 5%

C1= 0,21€

C2: TOOLING COST

For extrusion blow molding the cost Ct include dies, moulds, fixtures: one that must be wholly assigned to the production run of this single component. It is written off against the numerical size n of the production run. These data has taken from CES software.

Tool Cost: 30.000€
Pieces: 120.000
Tool life: 1.000.000
Payback Time: 7 years

C2= 0,25€

C3: CAPITAL COST

The capital cost of equipment, Cc, by contrast, is rarely dedicated. A given equipment an be used to make many different components by installing different die-sets or tooling. But in this case there is no part that it will be produced by extrusion blow molding.

Capital Cost: 1.300.000 €
Load Factor: 0,5

C3= 0,5€

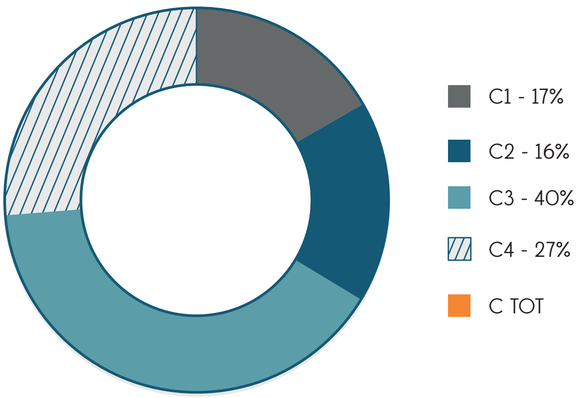
C4: OVERHEAD COST

Including the cost of labour, administration and general plant costs. Also there is the cost of information, meaning that of research and development, royalty or licence fees; this, too, we view as a cost per unit time and lump it into the overhead. Also this term is defined with CES softaware.

Indirect costs on the unitt: 40€/h
Production rate: 120 pcs/h

C4= 0,33€

For this project Ashby Cost modelling has been done to estimate cost for shaping operations. The manufacture of a component consumes resources each of them has a cost. The final cost is the sum of those of the resources it consumes. These are consumption of material, tools, capital and overhead.
The total shaping cost per part, Cs, is the sum of these four terms, these four terms investigated for min/max and mean values and cost estimations has been calculated :



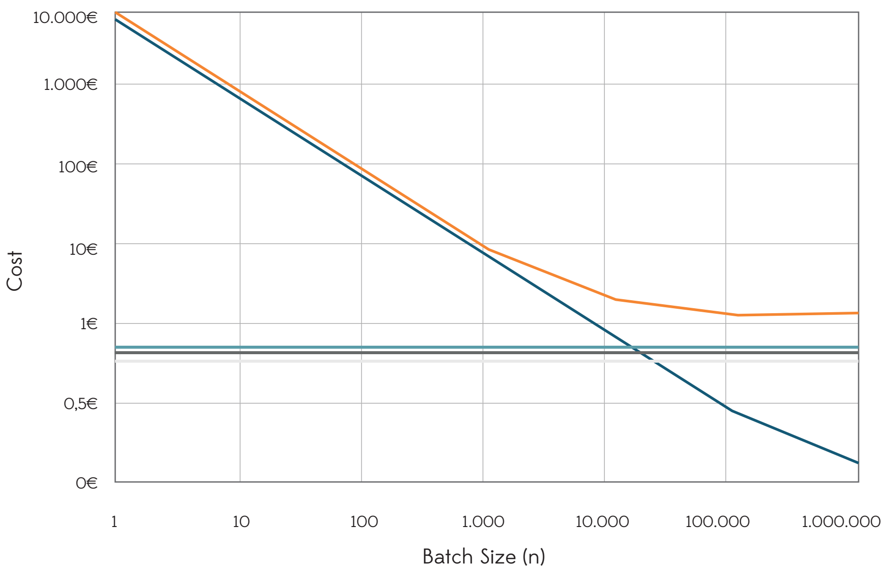


Chart 3.13: ICost Anal

Figure 3.43 : Product colour possibility

Conclusions

Nowadays the indoor air pollution is becoming a worldwide problem. Many studies, conducted by Prèuss- ¨Ust¨un et Corval´an (2016), EEA (2016), Lim et al. (2013) and others, have demonstrated that our society has a heavy and negative impact over the environment. Moreover they highlight the necessity of better understand the problem in order to find useful and operational solutions.

In this scenario, the interaction between users and measurements results in more precise information about pollutants.

The purpose of this project was to design an Air Monitor capable of detecting an excess of polluting elements and then being able to elaborate the best solution to ensure a healthy environment.

As explained in the previous chapters, we are only at the beginning of this strong trend that is changing our concept of wellness. It has been shown that, as the market is in an embryonic stage, there is an opportunity for a product.

Personally, I can be satisfied for the level of detail achieved, but the continuous evolution of technology such as AI and ML will increase the value of smart products and potentially they will be integrated with this solution.

The variety of subject areas covered made the development of this product-service very interesting, stimulating curiosity towards a highly debated concept such as pollution.

I have been able to put into practice many of the concepts assimilated throughout the studies, concepts belonging to different disciplines, which have come to merge in a single project, Air Things.

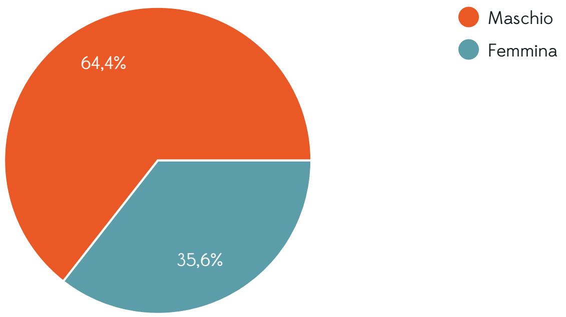
It can be said that Air Things was able to respond very well to the needs of the brief.

References

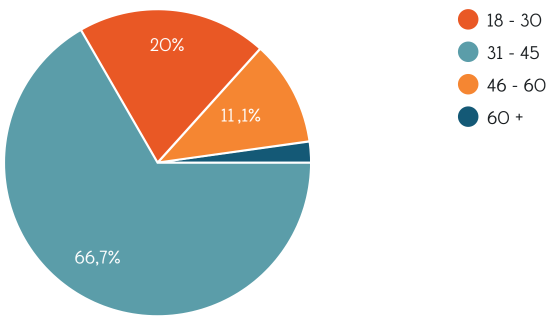
Attachments

Summary Results

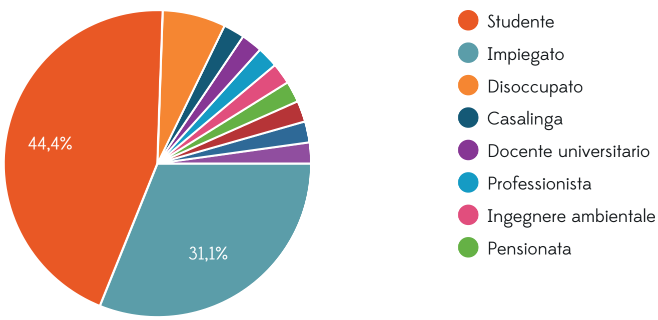
Sesso



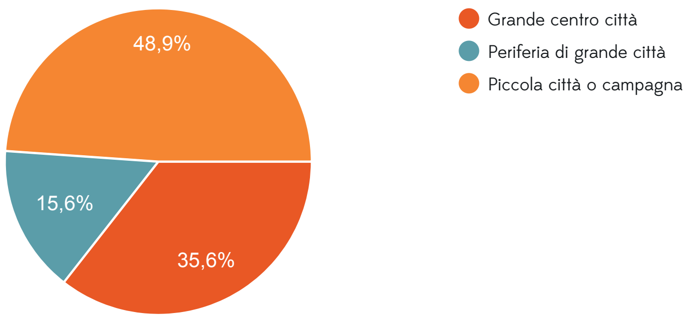
Età



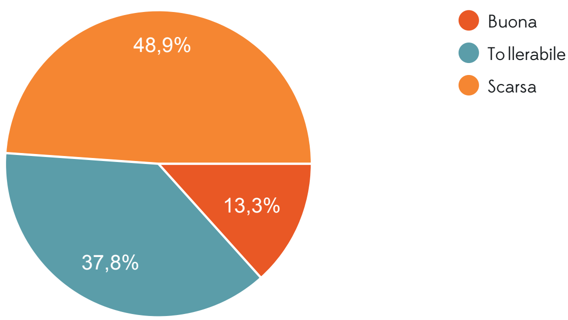
Di cosa ti occupi?



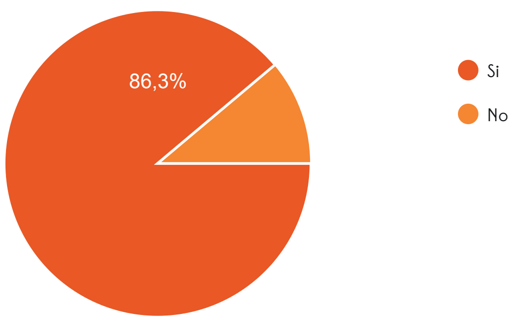
Dove vivi?



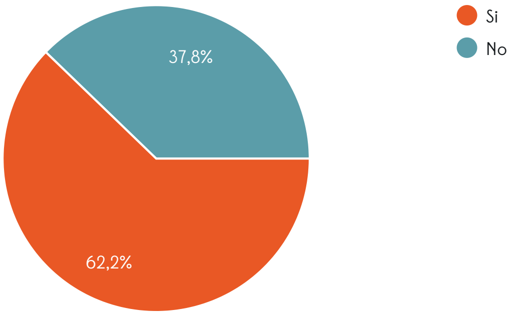
Come descriveresti l'aria che respiri?



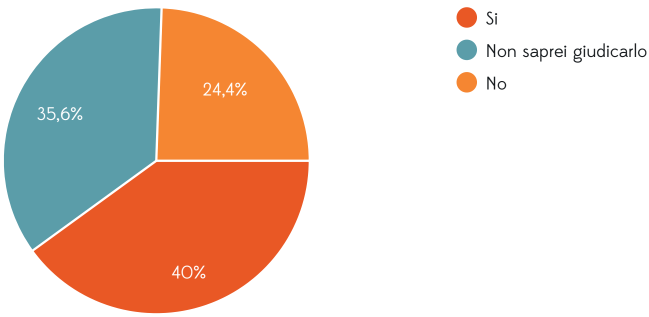
Sei preoccupato che la qualità dell'aria incida sulla tua salute personale?



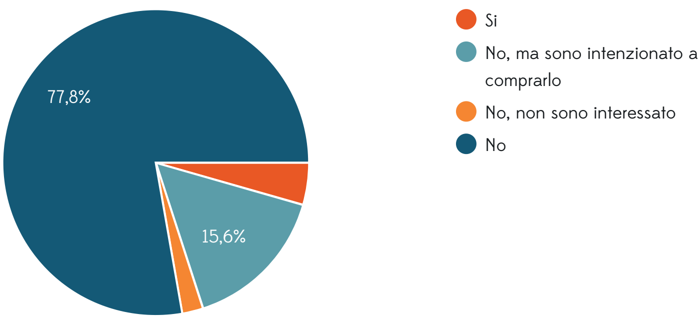
Eri a conoscenza che in media passiamo circa il 90% del nostrot empo in ambienti chiusi.
Essi possono essere fino a 5 volte piùi nquinati rispetto all'esterno.



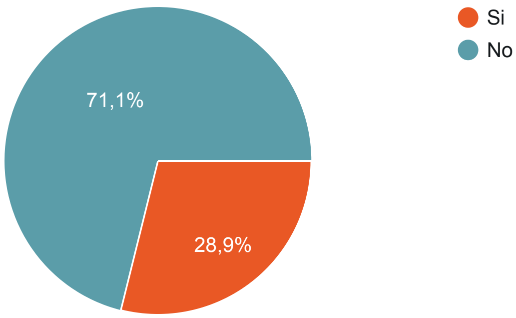
Hai mai avuto problemi legati all' aria che respiravi?



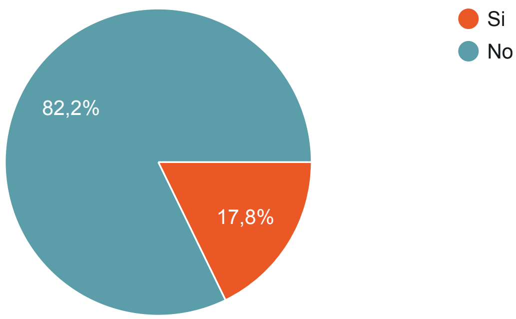
Sei in possesso di un dispositivo che ti consente di monitorare la qualità dell'aria ?



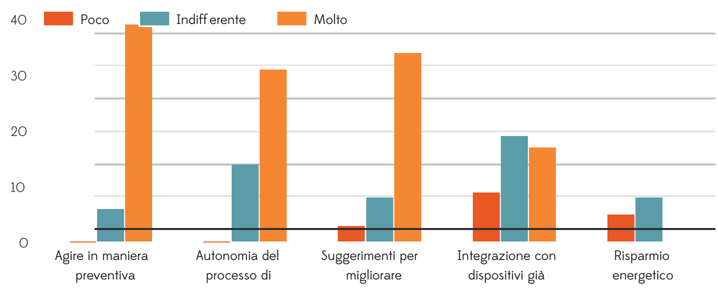
Se ti venisse indicato un elev ato tasso di inquinanti (NO2, COV, CO, PM 2,5) in ambiente domestico sapresti come interv enire?



E sapresti come poterlievitare?



Quali aspetti ritieni fondamentali in un dispositivocontro l'inquinamento?



Data sheet

POWER SUPPLY

iAQ-Core

Indoor Air Quality Sensor Module

General Description

The iAQ-Core sensor module is used to measure VOC levels and provide CO_2 equivalent and TVOC equivalent predictions. The data is available via I²C bus.

The sensor itself is protected by a plastic cap and a filter membrane. The sensor module can be soldered directly to a host circuit board with selective or reflow soldering via the edge connectors. The sensor is protected by a membrane, which should not be removed.

Note(s): Please read the I²C addressing instructions carefully. An undefined use of the I²C interface could harm the iAQ-Core module and cause a loss of functionality.

Ordering Information and Content Guide appear at end of datasheet.

Key Benefits & Features

The benefits and features of iAQ-Core, Indoor Air Quality sensor module are listed below:

Figure 1:
Added Value of Using iAQ-Core Sensor Module

Benefits	Features
• Reliable evaluation of indoor air quality	• Output of relative CO_2 equivalents (ppm) and TVOC equivalents (ppb)
• High sensitivity and fast response	• Sensing range: 450 – 2000 ppm CO_2 equivalents 125 – 600 ppb TVOC equivalents • I²C interface
• Micro size for convenient installation	• MEMS metal oxide sensor technology • SMD type package • Reflow capable • Module with automatic baseline correction
• Low power consumption	• 66 mW (maximum in continuous mode) • 9 mW (maximum in pulsed mode)

Applications

- Smart Home
- Internet of Things
- HVAC
- Thermostats

CARBON MONOXIDE (CO)

FIGARO PRODUCT INFORMATION

TGS 2600 - for the detection of Air Contaminants

Features:

* Low power consumption
* High sensitivity to gaseous air contaminants
* Long life and low cost
* Uses simple electrical circuit
* Small size

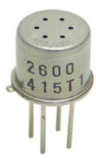
Applications:

* Air cleaners
* Ventilation control
* Air quality monitors

The sensing element is comprised of a metal oxide semiconductor layer formed on an alumina substrate of a sensing chip together with an integrated heater. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration.

The **TGS 2600** has high sensitivity to low concentrations of gaseous air contaminants such as hydrogen and carbon monoxide which exist in cigarette smoke. The sensor can detect hydrogen at a level of several ppm.

Due to miniaturization of the sensing chip, TGS 2600 requires a heater current of only 42mA and the device is housed in a standard TO-5 package.



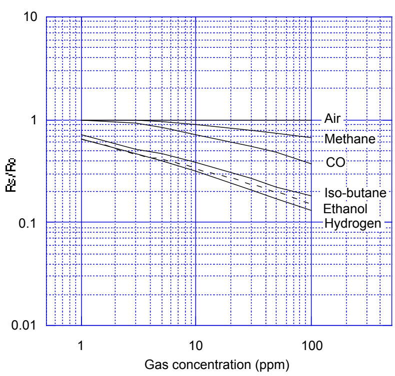
The figure below represents typical sensitivity characteristics, all data having been gathered at standard test conditions (see reverse side of this sheet). The Y-axis is indicated as sensor resistance ratio (Rs/Ro) which is defined as follows:

Rs = Sensor resistance in displayed gases at various concentrations
Ro = Sensor resistance in fresh air

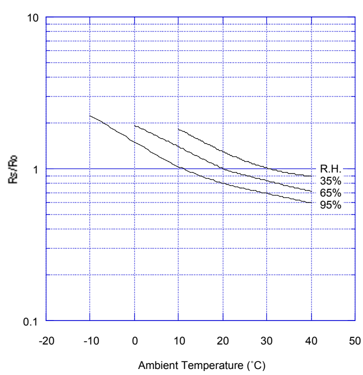
The figure below represents typical temperature and humidity dependency characteristics. Again, the Y-axis is indicated as sensor resistance ratio (Rs/Ro), defined as follows:

Rs = Sensor resistance in fresh air at various temperatures/humidities
Ro = Sensor resistance in fresh air at 20°C and 65% R.H.

Sensitivity Characteristics:



Temperature/Humidity Dependency:



<u>**IMPORTANT NOTE**</u>: OPERATING CONDITIONS IN WHICH FIGARO SENSORS ARE USED WILL VARY WITH EACH CUSTOMER'S SPECIFIC APPLICATIONS. FIGARO STRONGLY RECOMMENDS CONSULTING OUR TECHNICAL STAFF BEFORE DEPLOYING FIGARO SENSORS IN YOUR APPLICATION AND, IN PARTICULAR, WHEN CUSTOMER'S TARGET GASES ARE NOT LISTED HEREIN. FIGARO CANNOT ASSUME ANY RESPONSIBILITY FOR ANY USE OF ITS SENSORS IN A PRODUCT OR APPLICATION FOR WHICH SENSOR HAS NOT BEEN SPECIFICALLY TESTED BY FIGARO.

HUMIDITY

Datasheet SHT3x-DIS

Humidity and Temperature Sensor

- Fully calibrated, linearized, and temperature compensated digital output
- Wide supply voltage range, from 2.15 V to 5.5 V
- I2C Interface with communication speeds up to 1 MHz and two user selectable addresses
- Typical accuracy of ± 1.5 %RH and ± 0.1 °C for SHT35
- Very fast start-up and measurement time
- Tiny 8-Pin DFN package

Product Summary

SHT3x-DIS is the next generation of Sensirion's temperature and humidity sensors. It builds on a new CMOSens® sensor chip that is at the heart of Sensirion's new humidity and temperature platform. The SHT3x-DIS has increased intelligence, reliability and improved accuracy specifications compared to its predecessor. Its functionality includes enhanced signal processing, two distinctive and user selectable I2C addresses and communication speeds of up to 1 MHz. The DFN package has a footprint of 2.5 x 2.5 mm² while keeping a height of 0.9 mm. This allows for integration of the SHT3x-DIS into a great variety of applications. Additionally, the wide supply voltage range of 2.15 V to 5.5 V guarantees compatibility with diverse assembly situations. All in all, the SHT3x-DIS incorporates 15 years of knowledge of Sensirion, the leader in the humidity sensor industry.

Benefits of Sensirion's CMOSens® Technology

- High reliability and long-term stability
- Industry-proven technology with a track record of more than 15 years
- Designed for mass production
- High process capability
- High signal-to-noise ratio

Content

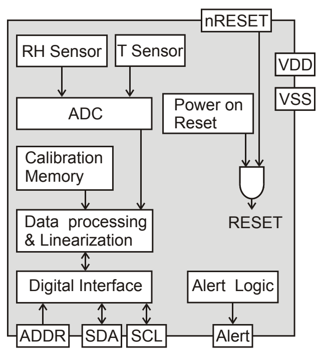


Figure 1 Functional block diagram of the SHT3x-DIS. The sensor signals for humidity and temperature are factory calibrated, linearized and compensated for temperature and supply voltage dependencies.

PARTICULATE MATTER PM 2,5

Particulate Matter Sensors
HPM Series

Table 1. Specifications

Characteristic	Standard	Compact
	HPMA115S0-XXX 	HPMA115C0-003  HPMA115C0-004 
Operating principle	laser scattering	
Detection [1,2]	PM2.5, PM10	PM1.0, PM2.5, PM4.0, PM10
Output data [1,2]	PM2.5 in $\mu g/m^3$, PM10 in $\mu g/m^3$	PM1.0 in $\mu g/m^3$, PM2.5 in $\mu g/m^3$, PM4.0 in $\mu g/m^3$, PM10 in $\mu g/m^3$
Concentration range	0 $\mu g/m^3$ to 1,000 $\mu g/m^3$	
Accuracy (at 25°C ±5°C): 0 $\mu g/m^3$ to 100 $\mu g/m^3$ 100 $\mu g/m^3$ to 1000 $\mu g/m^3$	**PM2.5:** ±15 $\mu g/m^3$ **PM2.5:** ±15 %	**PM2.5:** ±15 $\mu g/m^3$; **PM1.0, PM4.0, PM10:** ±25 $\mu g/m^3$ **PM2.5:** ±15 %; **PM1.0, PM4.0, PM10:** ±25%;
Response time	<6 s	
Supply voltage [3]	5 V ±0.2 V	
Switching frequency max.	100 kHz	
Ripple amplitude max.	20 mV	
R.M.S noise max.	1 mV (noise bandwidth 10 MHz)	
Standby current (at 25°C ±5°C)	<20 mA	
Supply current (at 25°C ±5°C)	<80 mA	
Inrush current max. (at 25°C ±5°C)	600 mA	
Temperature: operating storage	-20°C to 50°C [-4°F to 122°F] -30°C to 65°C [-22°F to 149°F]	-20°C to 70°C [-4°F to 158°F] -40°C to 85°C [-40°F to 185°F]
Humidity (operating and storage)	0 %RH to 95 %RH non-condensing	
Output protocol [4]	I2C; baud rate: 9600, databits: 8, stopbits: 1, parity: no	
Operating time: continuous mode intermittent mode	10 years depends on duty cycle	
Laser class	Laser Class 1: IEC/EN 60825-1: 650 nm	
ESD	±4 kV contact, ±8 kV air per IEC 61000-4-2	
Radiated immunity	1 V/m (80 MHz to 1000 MHz) per IEC 61000-4-3	
Fast transient burst	±0.5 kV per IEC61000-4-4	
Immunity to conducted disturbances radiated emissions	3 V per IEC61000-4-6	
Radiated emissions	40 dB 30 MHz to 230 MHz; 47 dB 230 MHz to 1000 MHz per CISPR 14	
Conducted emissions	0.15 MHz to 30 MHz in compliance with CISPR 14	
Dimensions (L X W X H)	43 mm x 36,00 mm x 23,7 mm [1.69 in x 1.42 in x 0.93 in]	44 mm x 36 mm x 12 mm [1.73 in x 1.42 in x 0.48 in]

[1] PM2.5 is particulate matter ≤2.5 µm in diameter; PM10 is particulate matter ≤10 µm in diameter.
[2] PM1.0 in $\mu g/m^3$, PM4.0 in $\mu g/m^3$, and PM10 in $\mu g/m^3$ are calculated from PM 2.5 readings.
[3] Power supply output should contain one de-coupling capacitor (22 µF), and two ceramic capacitors (100 nF, 10 nF), if ripple amplitude max. or R.M.S. noise max. exceeds specifications.
[4] Contact Honeywell for other output options.

CLASS 1
LASER PRODUCT

Table 2. Order Guide

Catalog Listing	Description
HPMA115S0-XXX	HPM Series PM2.5 Particulate Matter Sensor, standard size, I2C output
HPMA115C0-003	HPM Series PM2.5 Particulate Matter Sensor, compact size, I2C output, air inlet and air outlet on same side
HPMA115C0-004	HPM Series PM2.5 Particulate Matter Sensor, compact size, I2C output, air inlet and air outlet on opposite sides

2 sensing.honeywell.com

Additional Index

Figures

Charts

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