FROM IDENTIFYING TO ACTING: HOW TO GUARANTEE GOOD QUALITY AIR IN BUILDINGS

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Veolia's R&D teams are studying solutions targeting specific air quality problems, in partnership with leading research institutions

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1 Non-profit organization that monitors and studies atmospheric pollution in the Paris region.

The massive health impacts of air pollution have gradually put it firmly in the media spotlight, and almost everything we hear about air quality these days seems to be alarmist or resigned. Moving beyond doom-mongering to solve a major portion of the problem will demand solutions that are reliable, long-lasting and deliver guaranteed results – just like the approaches used to tackle other types of hard-to-deal-with pollution such as in water, hazardous waste and ground pollution. The same applies to indoor air pollution, which is another major public health challenge because we spend over 80% of our time in enclosed spaces. This attitude reflects the idea of the exposome[2], which guides public policies seeking to cut people's day-to-day exposure at every stage of their lives. It is also a response to strong pressure from society, which prefers to think of protection in terms of individuals.

For Veolia, guaranteeing air quality in a building means addressing the issue through three complementary approaches. First, it requires polluting phenomena to be diagnosed and described, identifying the nature of this constant and invisible form of pollution, and assessing its level. This is what we do through our AIR Control service. Then the pollution has to be treated by deploying techniques appropriate to the type of remediation required, as a function of the building type. This is our AIR Performance service. Lastly, and bearing in mind the impacts of air quality on individual behavior, associating the various stakeholders is essential to obtaining lasting results. This is our AIR Human service.

Schools, office buildings, hospitals and health care facilities, shopping malls, hotels, etc. – all are concerned and all need to provide good quality air to their users and occupants. New solutions are now available that rely on optimization of air treatment units developed for operating rooms and clean rooms, as well as on new continuous measurement technologies made possible by microsensors. Two levers are needed to support widespread rollout of these solutions: research and development to achieve commercial release of ever more innovative techniques that combine air quality with optimized energy use as a cost-effective package; and stronger regulation to introduce a performance obligation that will guarantee air of good quality, a process already seen in decisions recently enacted by some countries.

2 The "exposome" is a recent term that refers to the totality of harmful environmental, behavioral and professional exposure that people are exposed to throughout their lives. The exposome is used to identify and evaluate potential health risks so that individuals can better protect themselves and societies can reduce their health care spending.

INTRODUCTION

The entire world has to face the increasing prevalence of a new type of pollution: air pollution. It has emerged as the number one global environmental risk and a major challenge to public health. Outstanding efforts have been made to combat air pollution but the overarching trend points to a phenomenon that is getting worse, and the policy results appear inadequate. A few recent examples illustrate the anxiety of residents who increasingly refuse to live in polluted cities. In New Delhi, demonstrations in late 2016 protested slowness of government reaction to a toxic cloud that hung over the city for a week; China has seen over 500 daily protests against pollution since 2015; in Brussels, families have taken to the streets to demand action to fight air pollution, and so on.

Deliverable solutions exist for integrated comprehensive management of indoor air quality for public and private sector buildings

Authorities are starting to react at all levels. At the global level, the World Health Organization is currently drafting a new roadmap to strengthen the fight against air pollution and its causes[3]. At supranational level, legal action has been taken by the European Commission against countries that have failed to meet the requirements of the ambient air quality directives. At national level, states are tightening their legislation. China, for example, has made it a crime to manipulate air quality data. Municipalities and industrial companies are moving toward economic models that are cleaner, greener and less carbon intensive, with policies aiming to ensure that urban and industrial growth is compatible with protecting the environment.

Veolia has built up expertise to protect the health and wellbeing of residents. In terms of air quality, its know-how has existed for years, whether suppressing bad smells from sewage plants, scrubbing flue gas emissions and capturing volatile organic compounds from industrial activities, guaranteeing clean air in white rooms and hospital operating rooms, or running diagnoses and audits on air quality.

But much remains to be done and two macro levers must be considered. First is eradication of the sources of polluting emissions via upstream emission reduction and the development of business activities for modeling and measuring air quality, to evaluate the effects. The second concerns protection for people in enclosed spaces through the promotion of ventilation and filtration systems, indoor air pollution treatment and realignment of energy-efficiency regulations with health standards.

WHAT SOLUTIONS ARE THERE FOR IMPROVING INDOOR AIR QUALITY?

Expectations for indoor air quality are growing, in Europe in particular. In technical terms, increasing the impermeability to air of building envelopes – a corollary to the commitment to halve end-user energy consumption by 2050[4] – requires extremely precise and effective management of ventilation systems if good quality indoor air is to be maintained and Sick Building Syndrome avoided[5].

Rising demands are also being made by civil society. Issues of air quality are increasingly central to residents' and governments' preoccupations, as highlighted by Elabe's 2019 study of indoor air quality[6].

For a number of years, Veolia's research and innovation teams have been studying and creating solutions to three challenges:

- how to protect employees who are potentially exposed to inhalation of atmospheric pollutants;
- how to manage installations to maximize indoor air quality and energy efficiency;
- how to deliver solutions to specific problems raised by air quality.

Working in partnership with leading French research institutions such as Ineris, ANSES and Inserm, several tools have been developed to cut the exposure to chemicals of our employees and those of our clients in offices, hospitals and industrial sites. Internationally (Université Laval, Quebec, Canada ; Hong Kong University of Science and Technology, etc.), we have defined methods for reconciling energy efficiency with indoor air quality, including for chemical, biological and particulate contamination, during both the design and operational phases of ventilation and air treatment installations. There have also been innovations to help operational employees, particularly regarding predictive maintenance of air treatment units. Lastly, studies into the effectiveness of anti-bacterial coatings have made it possible to improve existing installations, and tools for monitoring and modeling emissions into the air, including bad smells, have been included in the water network and equipment supervision solutions offered by Veolia.

3 See the article by Maria Neira: Energy Transition for Better Air Quality: a Public Health Challenge

4 As required by France's Energy Transition for Green Growth Act, August 17, 2015

5 See the article by Fabien Squinazi: Managing indoor air quality to protect occupant health.

6 "La qualité de l'air intérieur," Elabe study for Veolia carried out in France, Belgium and Greater Shanghai, June 2019. See the relevant article elsewhere in this issue.

SOLUTIONS EXIST FOR FULLY INTEGRATED MANAGEMENT (DESIGN, INSTALLATION, PILOTING AND OPERATION) OF INDOOR AIR QUALITY, IN SYNERGY WITH ENERGY SERVICES

Our research translates operationally as follows: the first action is to fit buildings with sensors that continuously monitor air quality. Numerous environmental fields are seeing an explosion in the number of connected objects, and air quality is no exception. Sensors are being fitted to a growing number of cities, buildings, vehicles, and they equip people too. However, some sensors are not as effective as others, and not all are suited to every use. In the absence of standards, calling in an independent outside body to assess their reliability is vital, all the more as these sensors will be used for piloting air treatment units. We decided to ask Airlab[7] to run laboratory approval tests. We then ran on-site validation tests of the best sensors as part of our partnership with property developer Icade and at Veolia's head office, the V building in Aubervilliers. To receive approval, sensors have to meet criteria for cost, portability, ease of use, and accuracy for piloting indoor air ventilation or recycling, and be able to measure various parameters such as hygrometry, CO_2, fine particles and volatile organic compound levels.

Monitoring as a standard feature in buildings will provide large amounts of data on indoor air and new insights that will guide future rules for designing and operating buildings

The second focus is remediation via air treatment solutions. Open Innovation at Veolia has identified a number of responses, ranging from systems to integrate into existing air treatment units to self-contained units to place in a room to provide local air treatment. The most effective apparatus is chosen by running effectiveness tests on the systems to be deployed, looking at both technical and health benefits. Just the same as the reliability of measurement instruments is not a given, some reports[8] highlight the fact that the technologies are often little-understood and subject to efficiency claims that are hard to justify. Some poorly designed purifiers can even damage indoor air quality by creating new pollutants. Innovative ventilation solutions that deliver filtered air to occupied spaces in buildings and that are simple and cost-effective to deploy were also identified and tested. These are "reverse" solutions that blow filtered air into rooms, unlike traditional one-way extraction systems. This makes pre-treatment of outdoor air possible, which is not the case with one-way extraction. These offer efficient low-cost alternatives for mid-size buildings such as small schools that do not have a central air treatment unit. These solutions are also interesting for regions where radon gas is an issue.

Deploying these types of treatments involves meeting two challenges at once: delivering significant lasting improvement to air quality, and managing energy used for ventilation. Energy management and air quality issues are in fact intertwined. Most current energy efficiency projects involve increasing insulation and lowering the rate of air renewal in buildings, leading to the risk of trapping higher concentrations of pollutants in indoor spaces. This is why it is crucial to have this twin air-energy skill set to be able to roll out projects, whether new-build or refit, that meet the environmental and health challenges for buildings.

CANADA, MONTREAL – HEALTHY AIR FOR CHUM HOSPITAL

Centre Hospitalier de l'Université de Montréal (CHUM) in Canada was founded in 1996 as a result of the merger of three establishments. As part of an energy performance contract, Veolia was chosen to support the 2016 transfer of these three establishments to a unified new site. Questions relative to indoor air quality were central to this mission, including design, assistance, operation and risk management.

Considerable work went into the rotary heat exchanger systems (thermal wheels) used by the establishment's air treatment plants. Although very efficient energy-savers, these systems can suffer from problems with new air mixing with exhaust air, leading to questions about their suitability for sensitive sites like hospitals. The studies delivered recommendations for preventative and corrective maintenance to guard against this risk. The focus now is on work to identify how best to continuously assess microbiological risks in these systems.

7 Airlab is the air quality innovation platform run by Airparif, an accredited air monitoring non-profit where Veolia is a founder member. See the article by Karine Léger: Monitor, Inform, Understand, Innovate: the role of Airparif, a non-profit organization accredited by France's Ministry of the Environment to monitor air quality.

8 2017 report from ANSES: Identification and analysis of different emerging indoor air purification techniques

FRANCE – BETTER WORKING ENVIRONMENT FOR SOCIÉTÉ GÉNÉRALE BANK

OFIS, the Veolia subsidiary that specializes in audits of indoor air quality, has been helping the Société Générale banking group to improve the working environment of its staff for over 10 years. Société Générale asked it to monitor indoor air quality at its former head office and 30 other branches in Paris. Thanks to the plan of action put in place, Société Générale has been able to meet the highest air quality standards, providing optimal comfort to staff and customers.

CAN GOOD QUALITY INDOOR AIR BE GUARANTEED?

Controlling exposure to pollutants in enclosed spaces goes hand in hand with an engagement on the indoor air quality to be respected. Our goal is to work with building managers to guarantee healthy air, tied in with optimized energy management, to deliver increased wellbeing and comfort for occupants.

For Veolia, guaranteeing air quality in a building relies on approaches built around three complementary services:

- "AIR Control", covering expert knowledge, monitoring and auditing. This service is used to map the current situation and propose a plan of actions for improving air quality;
- "AIR Performance", incorporating management of technical installations combined with guaranteed air quality thresholds to meet. This is also offered as "AIR Performance Plus" in cases where capital investment is required to meet the client's air quality targets;
- "AIR Human", encouraging occupants to help meet targets. They then become actors in the solutions and their views are taken account of as part of performance criteria.

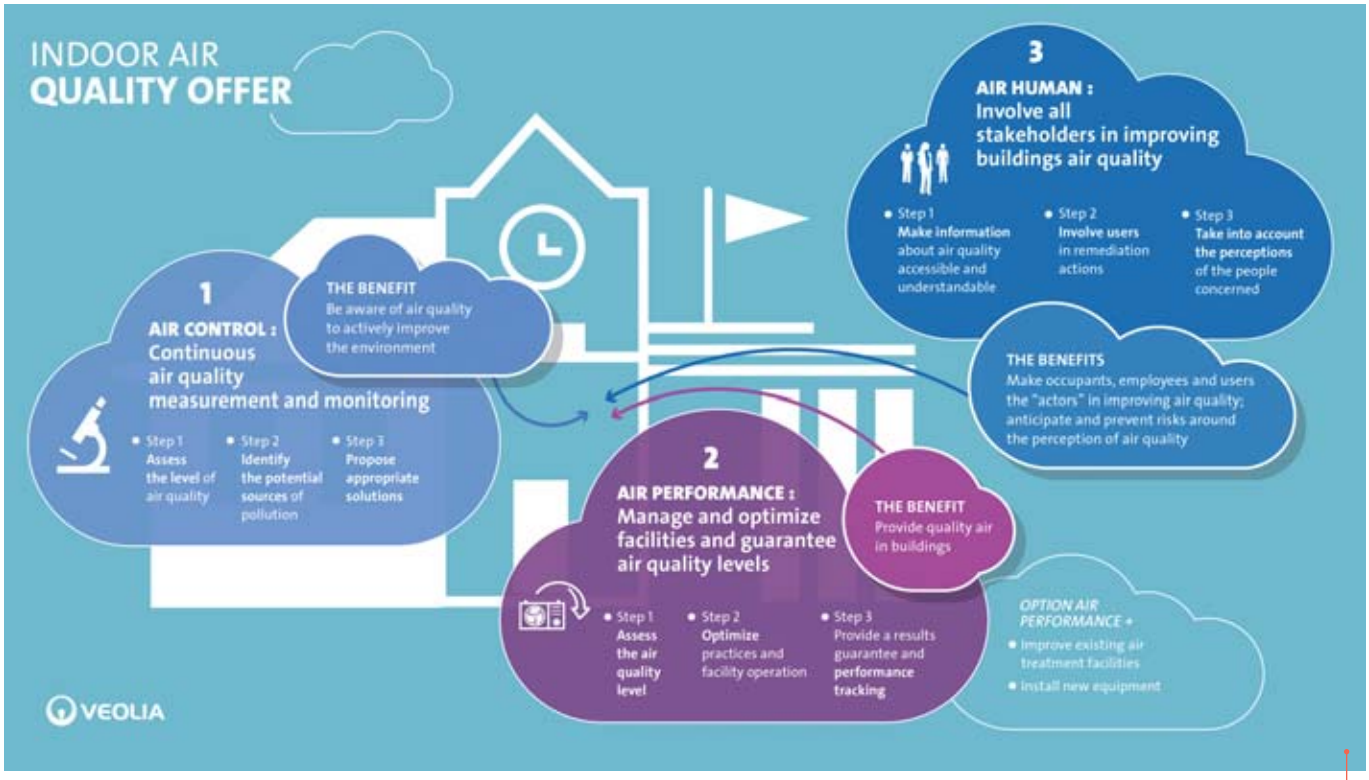


Figure 1: Veolia's three Air Quality Solutions

SINCE POOR AIR QUALITY HAS A GREATER IMPACT ON VULNERABLE PEOPLE AND CHILDREN IN PARTICULAR[9], SCHOOLS SHOULD BE PRIORITIZED

Preserving good quality classroom air is vital to learning and helping children to improve their concentration. Consequently, and for the first time in France, two schools in a municipality close to Paris *(see box)* were fitted with the new solution from Veolia (monitoring, treatment and awareness-raising). Since the start of the 2019 school year, every day almost 600 pupils and teachers breathe air that is guaranteed to meet WHO thresholds. Thresholds for fine particle concentrations[10], volatile organic compounds in the air, or the air confinement levels usually detected at most educational establishments are no longer exceeded in these two schools.

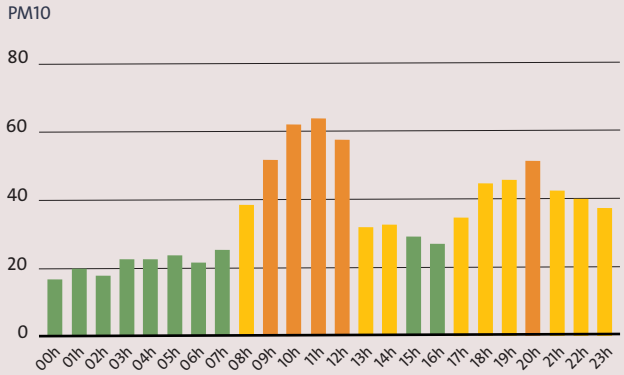
This is a major problem that can be found in many other countries, as illustrated by the example of Veolia Group teams in the Czech Republic.

9 Adults inhale 16 times a minute, compared to 40 times for children. This means that children are the most sensitive/exposed, especially as children form their respiratory system in the early stages of life.

10 In a representative study of 300 French schools, 93% of classrooms recorded concentrations of fine particles ($PM_{2.5}$) above the WHO guideline value - 2013-2017 study by Observatoire de la Qualité de l'Air Intérieur.

Particle measurements before and after use of *Air Performance*

Sep. 17, 2019 00:00 to Sep. 17, 2019 23:59



Nov. 04, 2019 00:00 to Nov. 04, 2019 23:59

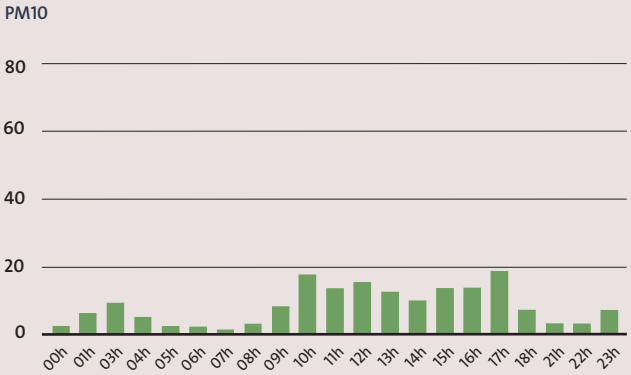
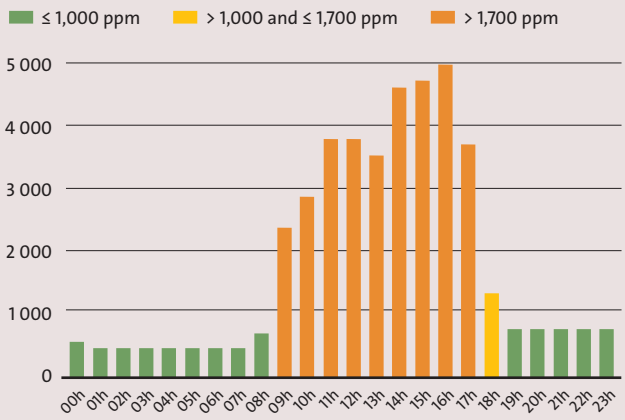


Figure 2

Measurement of CO_2 concentrations before and after use of *Air Performance*

Oct. 8, 2019 00:00 to Oct. 8, 2019 23:59



Nov. 19, 2019 00:00 to Nov. 19, 2019 23:59

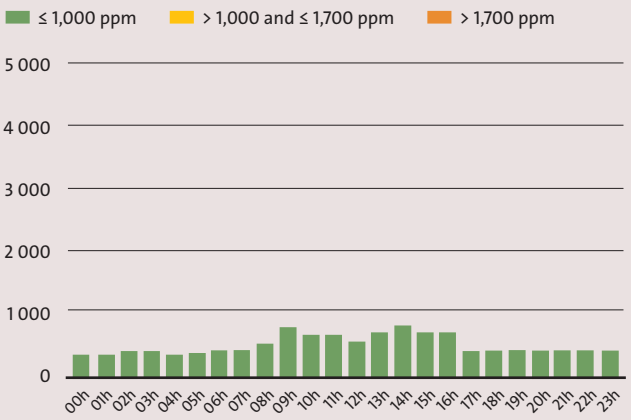


Figure 3

The same problem is to be found in many countries, as illustrated by the article on page 53 from Veolia in the Czech Republic.

Semi-centralised dual-flow air handling unit, La Fontaine elementary school (Le Raincy, France), class number 3 - © Jade Lachery

FRANCE, LE RAINCY: GUARANTEEING AIR QUALITY IN SCHOOLS

To mark France's national indoor air quality day on September 18, 2019, Le Raincy, a community of 14,000 people in the Paris region, announced an operation to deliver optimal air quality for its schools.

For Jean-Michel Genestier, mayor of Le Raincy, "a better understanding of air quality, via classroom sensors, was primordial in guaranteeing decent air to the 569 pupils at the schools involved."

Running at two elementary schools, this operation, from design to delivery, is an illustration of the three services – AIR Control, AIR Performance and AIR Human – offered by Veolia.

After auditing the buildings to identify sources of any pollutants that might be present in the classrooms, sensors chosen for their reliability were fitted to each classroom to provide continuous data about indoor air quality by measuring several parameters, including CO_2 and fine particles. The aim was to identify whether applicable regulatory thresholds were being exceeded.

Filtration and air renewal solutions were installed to guarantee pupils' air quality. These are piloted to ensure that the various air quality parameters are maintained below permissible thresholds while also optimizing energy use, as ventilation flow-rates are regulated according to real-time concentrations measured in each classroom.

And because there is more to guaranteeing air quality than just the technical aspects, experts provide advice and guidance on best practices through a set of teaching aids designed to make pupils active participants in the quality of the air they breathe at school and at home.

Lastly, in response to demands for information about air quality in schools from local politicians and residents, an indoor air quality dashboard has been created that summarizes air quality indicators in each classroom. The data is shared in total transparency with teachers and parents. Everybody is informed and aware of the positive impacts on air quality.

The solution fitted to schools in Le Raincy can be applied to other schools in France, 93% of which have high concentrations of particulate matter (exceeding WHO recommendations) and 41% have a CO_2 confinement index that is either very high or extreme.

BUILDINGS CAN BE SICK TOO: THE CASE OF THE CZECH REPUBLIC'S SCHOOLS

For many years, buildings have been undergoing insulation retrofits, where old wooden windows are replaced with plastic ones. This brings savings on heating, but the indoor air quality in sealed buildings deteriorates rapidly. This issue concerns over 60 % of schools all over the Czech Republic.

PROBLEMS WITH VENTILATION

The State Environmental Fund grants subsidies for insulating schools. "We provided support to a total of 1,200 schools and kindergartens to the tune of six billion crowns[14]." the Fund's spokesperson says, adding that more recent projects also include air conditioning.

However, school directors are now complaining that the savings made on energy are less than the new costs associated with the poor indoor air quality brought about by airtight buildings. They have to ventilate and air-condition regularly – and that costs money.

"The problem is acute, primarily in cold winter months when you cannot open windows that often to ventilate. Some children in classrooms sit near the windows and they feel cold very quickly. The other half of children do not even get a breath of fresh air because the windows are open for such a short time," says the director of a large school in Prague.

HOW HARMFUL IS A HIGHER CONCENTRATION OF CO_2?

Higher quantities of carbon dioxide affect both students and teachers – they get tired and their attention wanes.

Carbon dioxide is a natural component of ambient air, and it is a colorless and odorless gas. Living organisms produce it as a metabolite of cell breathing. In higher concentrations (>1,000 ppm) it affects human health, causing headaches, fatigue and loss of attention.

CO_2 concentration can reach about 1,500 ppm in a classroom during one lesson just due to the students and teachers breathing. After 90 minutes, it can be as high as 2,700 ppm. Increased fatigue and lack of attention become obstacles to teaching and learning.

"Our school underwent an overall insulation retrofit and window replacement a few years ago. Since then, air in classrooms gets stale much quicker and we have to ventilate more often. However, the children still get tired and sleepy. Some teachers also complain about greater fatigue," continues the school director.

Closed windows in classrooms full of children also cause a higher sickness rate. Infections are transmitted easier in environments with insufficient air replacement. Since there can be as many as thirty children in one classroom, the risk of infection is quite high. "Over time, we realised that fatigue was not the biggest problem. We did not see the connection initially; it was only after some time that we noticed the sickness rate among both students and teachers going up significantly."

HELP IS NOT EASY

Indoor air pollution is very difficult to detect just with human senses. This is why current buildings are fitted with sensors that measure the quality of the indoor environment. The sensors measure air temperature, humidity and CO_2 concentration. Based on these measurements, adequate ventilation actions are taken, preferably using an automatic system for controlled air replacement.

The current situation in many schools suggests that even regular manual ventilation is not sufficient for maintaining low CO_2 concentration levels in certain places. Automatic ventilation systems have become the only truly efficient solution for achieving user-independent low CO_2 concentrations over time.

"Having installed the detectors, we found that even opening windows frequently does not help. They say it is due to the windows being too tight," says one of the teachers. "We are currently addressing this issue intensively. Based on the available information, installing an active ventilation system is the most efficient solution to this problem. This is why we are collecting bids and we want to install the equipment in classrooms."

Thermal losses due to ventilation can be minimized using recuperation. Controlled ventilation ensures constant supply of fresh air and extraction of stale indoor air, regardless of the ambient conditions and without requiring the user's intervention. Healthy air in buildings is certainly worth the cost, though.

14 Close to 240 million euros.

SMART SYSTEMS FOR GOOD QUALITY INDOOR AIR: Interview with Martin Lang, Executive of LG Systems

Air quality in homes and schools is a hot topic these days. What are the consequences of poor indoor air quality? What's the solution? We asked Martin Lang from LG Systems Czech Republic, part of Veolia Group.

Lately, there's been much talk of worsening indoor air quality. Why is this happening?

Martin Lang: Buildings used to have natural ventilation thanks to their porous brickwork and windows and doors that weren't airtight. In the late nineties, large-scale insulation work began in the Czech Republic, supported by subsidies. Construction processes changed substantially, and there were great advances in how windows were made. Nowadays almost all buildings in the Czech Republic are insulated and fitted with new windows. The result is that there's no natural air exchange: in winter, condensation forms on the windows and mould starts growing. High humidity isn't the only problem. There's also a high carbon dioxide concentration indoors: the air gets stuffy and people don't have enough oxygen.

It's a major problem in buildings where there are lots of people: schools, hospitals, cinemas, theatres. In new construction projects, this is solved using heat recovery systems, but older buildings don't have them.

What are the consequences of higher indoor CO_2 levels?

M.L.: Lower immunity: in insulated school buildings, sickness levels are as much as twice as high as before. What's more, if there's not enough oxygen, the body will try to maintain its basic functions, at the expense of more depending brain activity. That results in fatigue, drowsiness and poorer academic performance, which is particularly problematic for schools.

Studies show that if a classroom is briefly ventilated, just ten minutes later CO_2 levels are too high again... You can't fix this by having the window open all the time – it results in substantial heat losses that weren't part of the plan, plus there's noise, which makes teaching difficult.

What proportion of schools does this apply to?

M.L.: It affects the majority of Czech schools. These are schools where the buildings were insulated without heat recovery systems.

What about other countries?

M.L.: The situation is similar. In the 1990s, all of Europe started talking about global warming, and environmental movements became more powerful. The result was a revolution in construction, favoring buildings with low thermal energy consumption. Today, other countries are facing the same problems we are. Lots of buildings that were insulated earlier haven't been fitted with heat recovery units.

What's the solution?

M.L.: Our company has developed a smart system to help optimize how homes function. The heart of the control system is a microcomputer that receives information from sensors. These sensors record various things, including indoor air quality, CO_2 levels and humidity – and if the limits are exceeded, the system alerts the user that the home needs ventilating. The system can also judge whether humidity is due to the fact that you're in the shower and it'll go down again, or whether it's longer term and you really need to ventilate. Smart heat recovery windows also substantially improve indoor air quality, although generally windows have to be opened and closed manually. Automatic opening and closing is possible, but for users it's not always desirable. A window might open in the room where the family is watching television, and they won't want any draughts or noise from outside.

What else can your smart system do?

M.L.: Our system means that the whole home is smart, and users can access all of the outputs from their computers or mobiles. The system can control central heating thermostats to optimize comfortable temperatures. Users can turn up the heating remotely if they're coming home from a weekend away. The system can turn lights and plug sockets on and off, using the existing fittings rather than dismantling or replacing the switches. If you're going away on holiday, our smart system can simulate movement in your home by turning the lights on and off and opening and closing the blinds, and it can switch off the majority of electrical circuits to avoid any accidents. We're planning to add a smart fridge or pantry that will do your food shopping automatically.

Our smart system also lets you check your water, energy and heat consumption remotely online. It shows your consumption in standard units and in koruna (Czech Republic local currency), with a forecast for your annual bills, and it will also highlight any anomalies. That means users can easily check at any time whether their monthly payments are sufficient rather than worrying about high heating, water and electricity bills at the end of the year.

You mentioned smart windows. What can they do?

M.L.: We are currently offering a smart window that includes a smart blind and an integrated heat recovery unit in the frame. It's particularly suitable for homes, and you don't need recovery units for all the windows in the room – the number of units depends on the size of the room that needs ventilating.

What else is in the pipeline?

M.L.: We're hard at work on the next revolutionary step in smart windows. We want to fit them with heat pumps to facilitate cooling and heating. To do this, we use a classic double-glazed window and install a third pane on it, with an integral smart blind and heat recovery unit. There are vents on the edges of the frame and "pockets" approximately fifteen centimeters long in the walls. Our unique smart window is then able to optimize the indoor air quality without having to open or close, just by adjusting those edges and pockets. It'll find application in flats, houses, schools, kindergartens, medical facilities, office buildings and other premises.

EVEN IN NEW-BUILDS INCORPORATING INDOOR AIR QUALITY CRITERIA, HEALTHY AIR REMAINS AN IMPORTANT ISSUE FOR OPERATORS

For our new head office, the "V" building, we set ourselves the target of achieving health and environmental excellence. This meant that ensuring good indoor air quality for all the building's users was one of the key challenges identified during the construction phase. The building was constructed to meet HQE® Excellent and BREEAM® Very Good certifications, meaning that it incorporated ambitious indoor air quality targets. The choice of materials to limit emissions of chemical compounds, the selection of efficient air treatment systems and the installation of over a hundred CO_2 measurement sensors all helped ensure that the building performs as intended. Today, in addition to annual air quality audits, the "V" is covered by our AIR Performance service, with air quality piloting that includes a performance guarantee. This new obligation has highlighted variations that previously went unnoticed and can potentially impact occupant comfort. For instance, alterations to how spaces are used, such as construction of a new partition or modification to an open space, can have knock-on effects on air quality that, in the absence of any adjustment to the ventilation system, are not properly compensated for. Similarly, continuous monitoring from the installation of almost 40 extra sensors to measure fine particles, CO_2 and volatile organic compounds provides enhanced insights into the variation of air quality's different parameters and allows adapting the control of air handling units accordingly.

This is an approach used in other parts of the world too, as illustrated by our Chinese colleagues.

VEOLIA IN CHINA

In China, companies that are able to offer complete monitoring solutions (for instance online monitoring of several air quality parameters with the required accuracy, smart monitoring, operation and data processing) are expected to have a competitive advantage in the future.

In that regard, Veolia has decided to reinforce its portfolio of services in China, since it expects Indoor Air Quality (IAQ) to become an important booster for Building Energy Services offers.

To demonstrate its legitimacy to operate in China, our company became the main shareholder of *DasLinkin*, a local company specialized in electricity services. This partnership will help to grow Veolia's network and geographic presence as well as its technical expertise in High Voltage & Low Voltage electricity services.

Linkin by Veolia developed an Indoor Air Quality pilot project in one of our contractual showcases; the Shanghai Pudong Water Concession:

- The team started by carrying out an indoor air quality audit in the office building and installed 11 sensors in various areas of the building[11] to track five indicators *via* a monitoring platform. According to the temperature, humidity level and concentration of CO_2, $PM_{2.5}$ and VOC, the platform could automatically provide operational guidelines to the end users.
- In the meantime, proactive actions have been launched to improve air quality. For example, the local team allowed a retrofit on the Air Handling Unit (AHU) device to improve $PM_{2.5}$ and VOC levels. Smart mobile air filters were also installed to automatically move across the office according to varying air quality needs.
- Finally, electricity consumption was integrated into the tracking platform to identify ways to reduce energy use.

Following on from the Indoor Air Quality monitoring pilot project, the ambition is now to allow the scanning and remediation of air pollution.

11 Ie. the lobby, meeting room, control room, open office area, pantry and outside of the building

This twofold action – continuously measuring indoor air quality at the same time as offering solutions to improve and conserve it — allows us to work with building managers, who were previously hesitant in the face of this complex and troubling problem and may have been tempted to downplay it. This is why our approach usually starts with the AIR Control service. Initial diagnoses combined with continuous monitoring give a detailed dynamic overview of the status of a building, showing the footprint of its indoor air quality. Once this is known, it becomes easier to suggest solutions to remedy any problems encountered.

This type of solution can be adapted to a very wide range of buildings: hotels, hospitals, sports centers, shopping malls, swimming pools, etc. We are continuing to work on solutions for treating specific complex types of pollution encountered in unusual atmospheres such as underground, including metro systems.

As the market grows, prices for measurement and treatment equipment will likely become even more cost effective, and growing volumes will accelerate wider use of indoor air quality treatment to deliver health uplifts to all. As shown in a paper published recently by Paris city council's Urban Lab[12] on a raft of air quality experiments, regulation will be an effective mechanism for supporting development of these solutions. The very recent example from Belgium,[13] which has switched from a process-based system to one that imposes an obligation to achieve results and guarantee indoor air quality, paves the way for tighter regulatory requirements that offer greater protection to human health.

CONCLUSION

Air is a common good and vital resource for us all – we each breathe 15,000 liters of it a day. From now on it is possible to guarantee good quality indoor air in buildings, and in so doing to reduce the major health risks air pollution poses. The primary challenges in the coming years center on having the capacity to deliver a widespread, rapid rollout of the solutions that are developed, and to optimize costs per cubic meter of treated air. In a broader sense, monitoring as a standard feature in buildings will provide large amounts of data on indoor air and new insights that will guide future rules for designing and operating buildings.

12 The laboratory for urban experimentation run by Paris&Co.

13 A royal decree of May 2, 2019 amends the Code on workplace wellbeing with regard to indoor air quality in workspaces.