TROX life

magazine no. 14

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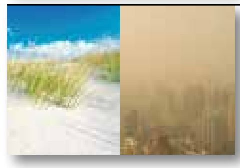

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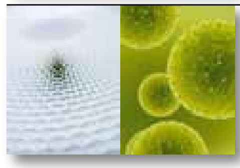

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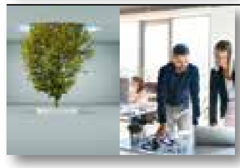

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Indoor life quality.

Air is life. Humans can survive for weeks without food, but only for a matter of seconds without air. We all know how good it feels to take a deep breath of fresh air in the mountains or at the sea.

TROX – The art of handling air. For 25 years we have cultivated this art. For 25 years this has been our mission. Our advanced components, units and systems complement one another perfectly, and they are a decisive factor in the creation of an ideal indoor climate in which people can thrive.

Now we are taking things one step further: 'TROX. The art of handling air – for indoor life quality.' This is our mission for the years to come. Clean, fresh air has a direct impact on people's quality of life. Clean air is safer and improves their health, helps them to perform better, and gives them the energy they need to live their lives. We are committed to developing intelligent ventilation and air conditioning systems for the buildings of the future, committed to creating complete systems that integrate all our components, committed to creating systems that provide fresh air and comfort wherever people are working, staying, relaxing, shopping, doing sports… In one word: living. The human being is the yardstick, and people's well-being is our goal.

Our vision as the independent TROX GROUP is to be one of the major global partners for ventilation, air conditioning, fire protection and smoke extract systems in our increasingly digital world.

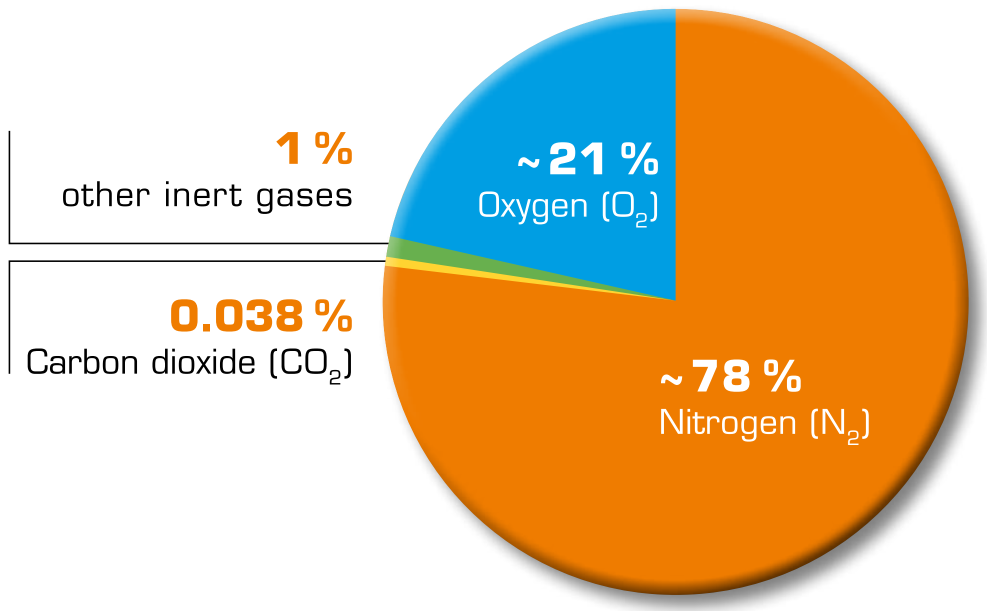
This issue of TROX life – entitled 'Air and Life' – covers a multitude of fascinating topics surrounding the air we breathe, with a focus on indoor air quality. We report on commendable indoor air conditioning projects that have one major goal: to improve the well-being, health and comfort of room occupants. We cover the latest scientific findings and research projects geared at achieving the best possible indoor air quality and environment for living, working and learning. And we share some funny air-related facts and anecdotes, too. As a matter of fact, though, the importance of really good, healthy indoor air has not yet been fully appreciated by the wider public. Our hope is that this issue of TROX life will help to increase awareness and broaden understanding of just how important indoor air quality actually is.

I hope you enjoy reading our magazine.

Udo Jung
TROX Board of Management

Air is life.

Air is a mixture of gases from the Earth's atmosphere, comprised primarily of nitrogen (approximately 78 vol%) and oxygen (approximately 21 vol%). Each day, a person takes more than 23,000 breaths, displacing around twelve and a half cubic metres of air.



The air we breathe.

The oxygen in the air we breathe is critical to the survival of all aerobic[1] life forms. Via the breaths we take and via our skin, oxygen makes its way into our bloodstream and is transported to our metabolic systems. Through a process of catabolism, metabolic products are converted from complex molecules into smaller, simpler units. These molecules detoxify and energise the body. The carbon dioxide from the cells and tissues is diverted to the lungs via the bloodstream, where it leaves the body on exhalation.

Plants use the carbon dioxide in the air for photosynthesis. By utilising the light-absorbing pigment chlorophyll, they convert light energy into sugar and oxygen, transforming inorganic, low-energy carbon dioxide into organic, energy-rich substances. Plants release their oxygen back into the air to complete the cycle.

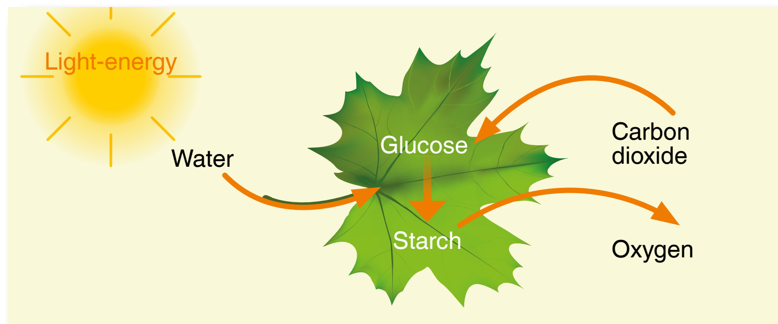
During this organic process, virtually all of the oxygen in the air is regenerated. This constant replenishment ensures that both aerobic life forms and photosynthesising plants enjoy continuous access to the resources they need to survive.

[1]Metabolic processes that take place in cells or organisms are defined as aerobic if they only take place when oxygen is present in the air (for oxidation and respiration).
[2]2012

Increasing air pollution.

However, the air also carries dust and other particles, such as pollen, fungus and fern spores. In addition to these natural materials, countless other gaseous pollutants – created as by-products of natural and man-made processes – make their way into the atmosphere. Increasing emissions of hazardous substances across the world are contaminating the air we breathe. According to statistics published by the World Health Organisation, around eight million people die prematurely each year due to fine particulate air pollution; 4.3 million of these deaths can be ascribed to indoor air pollution[2].

While dust and pollution affecting ambient air is a widely recognised issue, the quality of the air we breathe indoors is nowhere near as high on the agenda for the general public. However, if we consider the fact that we spend 90% of our time indoors, it becomes clear just how critical good indoor air quality (or IAQ) is to our health.



Indoor air quality – IAQ.

The positive effects of good room air quality are beyond question: High-quality air boosts well-being and improves performance. Infections and allergic reactions caused by airborne bacteria and particles are kept at bay, resulting in fewer days lost to illness.

For maximum energy efficiency, building shells are now being sealed with ever-greater care to prevent unwanted heat losses. For this reason, mechanical ventilation is an essential component of any modern building. A further aspect to consider is the high level of fine particulate pollution prevalent in the ambient air in many parts of the world. Contrary to popular belief, it is not a lack of oxygen that causes symptoms of tiredness, but in fact the high level of particulate pollution and chemical substances in the air. Ventilation and air conditioning systems are designed to filter the polluted ambient air and to ensure that the air inside buildings is refreshed and regenerated at an appropriate rate.

IAQ is a crucial factor in economic decisions.

If a company's accounting department wants to evaluate the economic feasibility or performance of a ventilation and air conditioning system, it is likely to base its assessment primarily on energy costs. However, these figures can be grossly misleading: Energy costs account for just 1 percent of the cost of providing a workspace for an employee, but the increased performance and decreased absenteeism that these systems bring is a much greater economic benefit to the company. Schools fitted with appropriate air exchange systems have identified a direct correlation between air quality and lower absenteeism, achieving reductions of between 10 and 20 percent. With these results in mind, comfort and health factors have once again moved up the agenda for standards committees, earning a place alongside efficiency as key considerations – as evidenced by the new filter standard (see also p. 18 ff.).

How is room air quality measured?

The scientific and research communities are working tirelessly to develop methods to quantify room air quality and its effects (see also the interview on p. 40 ff.). Thanks to intelligent control and sensor technology, AHUs are able to record, evaluate and respond to measurable parameters. However, alongside these factual parameters, the subjective experiences of each individual also play a key role in evaluating room air quality.

Technical measurement parameters:

- CO_2 as an important indicator for man-made air pollution.
- VOCs – volatile organic compounds: Sources include plastics, construction materials, furniture, flooring, cleaning products, tobacco smoke and human body odours.
- Particles caused by wear, technical installation and ambient air pollution.
- Humidity, important for comfort and health.
- Air temperature, can be recorded objectively in °C, but experienced subjectively by individuals as operative room temperature.

Individual parameters:

- Temperature preferences: Every individual has their own preferred comfortable temperature.
- Sense of smell: The nose is a highly sensitive organ capable of detecting many different substances in very low concentrations. However, the nose is also very selective. Not all substances are perceived in the same way. This is why we have not yet been able to develop a technical measurement solution to assess the odours in the environment, such as the odour of construction materials: Only the human nose is capable of evaluating the quality of a smell!

If you wish to take a wider view of indoor well-being and also take factors such as light and optics into account, the measure is instead referred to as IEQ.

IEQ – indoor environmental quality: Environmental factors

- Thermal comfort
- Air quality
- Acoustics
- Lighting
- Optics, colours
- Architecture, views
- Ergonomic aspects

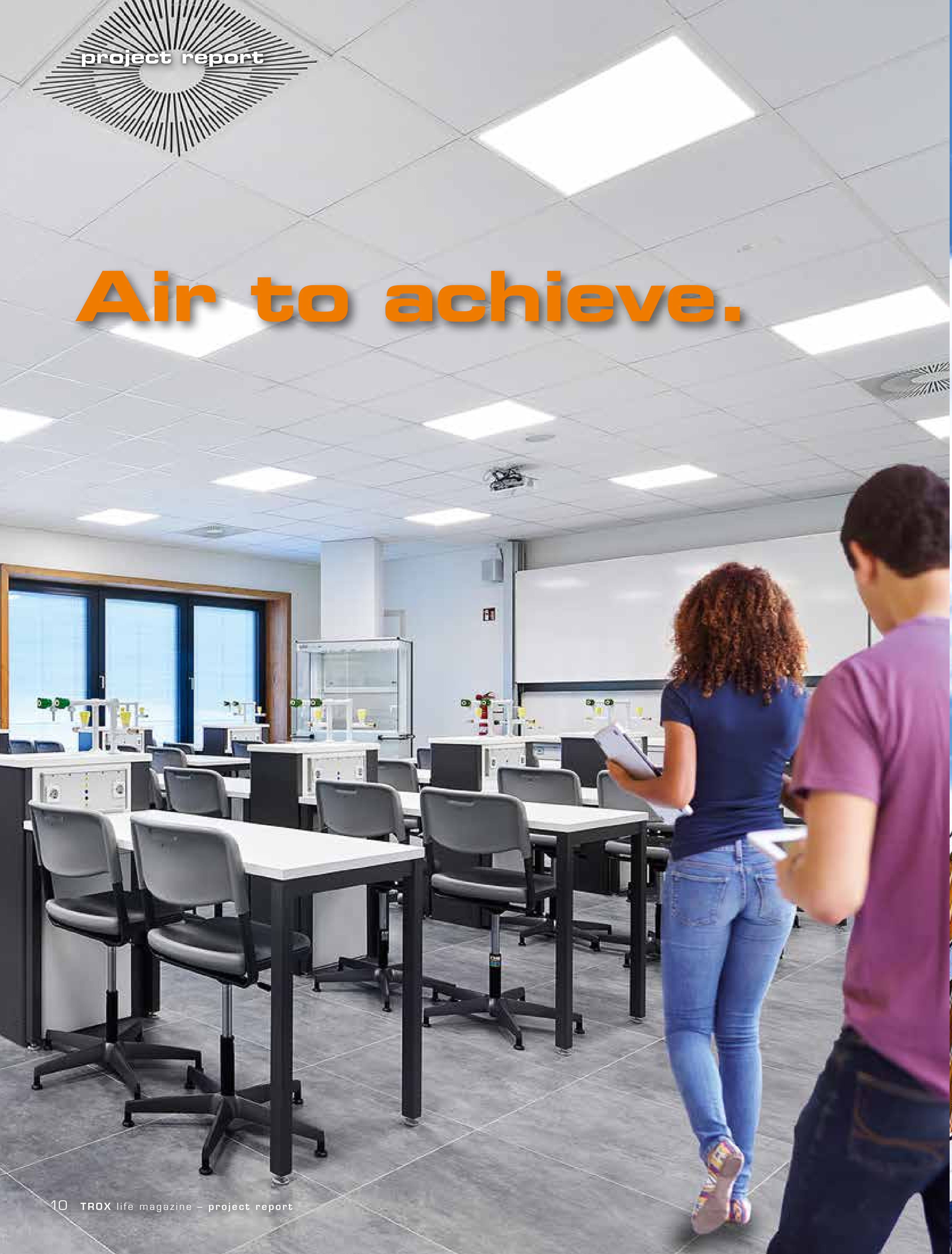
As room air quality is a subjective variable that is experienced differently by different individuals, there is no way to please everybody. Generally, at least 15–20% of room occupants in an open-plan office without individual control options will be dissatisfied with the room temperature or the room air quality. Researchers are striving to rectify this unsatisfactory situation, but they are faced with a difficult task: Thermal comfort and air quality are largely subjective parameters that cannot be measured objectively. Instead, systems are designed, planned and operated in a way that allows the users' interaction with the technology to be measured. Research teams systematically analyse the user behaviour data gathered during field tests. Their eventual aim is to develop stochastic[1] user models and 'parameters' for rating comfort levels through testing and comfort simulations, and to apply these results in complete system simulations.

Supporting science.

'The human being is the yardstick, and people's well-being is our goal' – this is how Heinz Trox summed up his life's work. When setting out his vision for the foundation set up in his name, Trox placed great emphasis on providing long-term support for research and the next generation of scientists, particularly in the field of air conditioning technology. For this reason, the Heinz Trox Foundation became the non-profit company Heinz Trox Wissenschafts gGmbH. The company works across organisational and sector boundaries, developing research projects that aim to increase well-being indoors and seeking to balance comfort and ergonomics with the need for increased energy efficiency.

[1] Just as it is impossible to predict how some systems will behave, it is also impossible to predict how people will assess room air quality. Stochastic models based on probability calculations are used to model these kinds of systems.

Air to achieve.

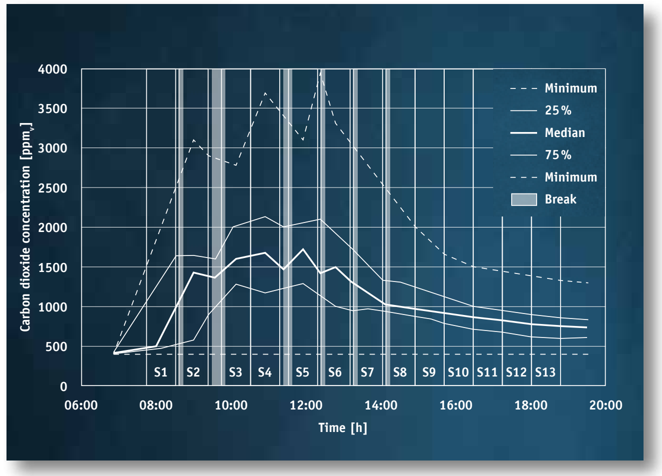


A school in the Diocese of Osnabrück in Germany knew that providing the best possible environment for students would improve their performance – so it planned and fitted out its new science wing accordingly. Part of the school's plan was to ensure adequate air exchange in the classrooms, with the aim of keeping the level of CO_2 below 1,000 ppm.

GYMNASIUM MARIANUM MEPPEN

IAQ for IQ at the Gymnasium Marianum Secondary School.

As early as the 19th century, Max Pettenkofer conducted multiple tests of the carbon dioxide content of air in schools, and compared the results with the olfactory impressions of the room occupants. Based on his findings, he concluded that the carbon dioxide content must not exceed 1,000 ppm – the Pettenkofer value that is still applied today. Modern scientists such as Pavel Wargocki have studied the effects of high-quality room air on the performance of students, and found that doubling the outdoor air rate increased the speed at which students could solve a maths problem by an average of 14%. The latest scientific findings prove beyond doubt that better room air quality increases performance and well-being and significantly reduces allergies, infections and the associated absenteeism.

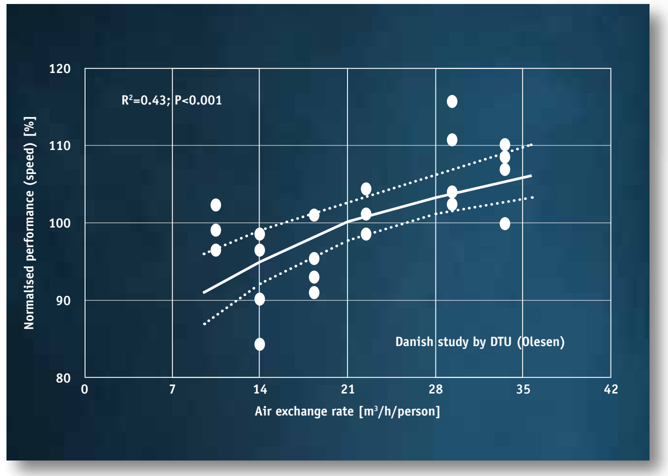


For 80% of the time students spend in lessons, the room air conditions fall below an acceptable standard.
Source: Hellwig, R. T.; Antretter, F.; Holm, A.; Sedlbauer, K.: Studies on indoor climate and opening windows in schools

Labs for the next generation of researchers.

The Gymnasium Marianum Secondary School in Meppen, Germany, is a Catholic private school managed by the Schooling Foundation in the Diocese of Osnabrück. The school is attended by around 1150 students and employs approximately 90 teachers. The landscaped grounds on the southern side of the abbey, the 1.3 hectares of meadows and orchards, the school garden and the beehives all promote learning and complement the school building.

The school recently added a new three-storey building for biology, physics and chemistry to its complex, which includes a listed abbey dating back to 1901.



The students' performance is demonstrably increased as the supply air flow increases
Source: Wargocki, P.; Wyon, D. P.: Environment Affects Performance. ASHRAE Journal March 2013

The new building provides the perfect environment for students of these subjects to gain a solid and innovative scientific education. Students can use the new wing to investigate, experiment, analyse and research. The new chemistry labs are fitted out just like research laboratories, complete with professional lab equipment and cabinets and a professional-grade storage room for the substances and tools used for experiments.

Lab conditions require a specific ventilation concept.

In environments where experiments are conducted with damaging and hazardous substances – as is the case in the new science wing at the Marianum Gymnasium Secondary School – the room air distribution concept must achieve exceptionally high standards of safety: No dangerous concentrations of gases, vapours or dusts can be allowed to enter the labs via the fume cupboards.

Each of the laboratories on the second floor of the new science wing is fitted with roof-mounted extraction fans to remove the required volumes of air from the fume cupboards. The extract air flow determines the required supply air flow. The extract air volume flows depend on the type and size of the laboratory and the fume cupboards and extraction units used. As well as maintaining the room air balance, the room air control system must also adjust pressures as necessary to prevent substances from escaping from the laboratory and into the building interior. The drawers used to store chemicals are also integrated into the extraction system, allowing the extract air to be drawn out of the cabinets.

Professional laboratories

An adequate rate of air exchange in the classrooms boosts student performance

Cabinets integrated into the extraction system and used to store chemicals.

X-CUBE air handling unit for a volume flow rate of 22,000 m³/h.

Intelligent ventilation.

To ensure maximum safety and comfort in the classroom throughout the day, the components of the ventilation and air conditioning system are connected in a network. An intelligent air management system records all relevant data, evaluates this data and controls the system based on the specified parameters.

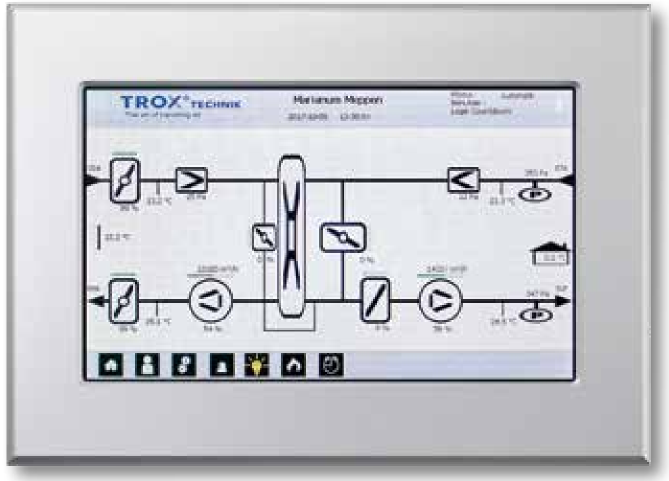
The new science wing was fitted with an X-CUBE AHU with a volume flow rate of 22,000 m³/h and equipped with high-efficiency PM* motors. The X-CUBE AHU heats and cools the rooms in the new building. According to Jens Hawighorst, Technical Manager for the Diocese, the building's passive construction means that the heating system in the rooms only needs to be switched on rarely, on exceptionally cold days.

* permanently magnetised synchronous motors

The X-CUBE AHU heats and cools the rooms in the new building.

Intelligent room control for complete ventilation comfort.

The X-CUBE control system is integrated into the AHU. It is also intelligently networked to the ventilation components to ensure that each of the rooms and room areas are controlled with maximum efficiency, depending on occupancy. Sensors for room occupancy, air quality and temperature report their measured values via the control modules to the higher level X-AIRCONTROL controller, enabling fully demand-based room control. In the 28 zones distributed across three floors, zone master modules – complete with interfaces to the central building management system – manage the controlled air supply. Thanks to X-AIRCONTROL technology, establishing a network with the central BMS interfaces of the older building was a simple plug and play process. Furthermore, a modem was connected to the switch cabinet in the new building to allow the system to be monitored remotely.



The X-CUBE control display can be used to view various parameters.

The display of the AHU allows the user to call up parameters and to view, track and document automated or manual function tests, for example on fire dampers connected via the TROXNETCOM system. Standard communication protocols allow for the seamless integration of TROXNETCOM and higher-level building automation systems.

The chemistry rooms are not constantly used for experiments. They also function as 'normal' classrooms. In such situations, the teacher can operate a key switch in the teaching area to switch the ventilation from laboratory mode to standard mode. This switch reduces the air supply, as the required rate of air exchange is significantly lower when the space is being used as a classroom rather than a laboratory. This option saves valuable energy and boosts climate comfort.

Efficient air distribution.

XARTO swirl diffusers integrated into the ceiling grid in the classrooms and corridors ensure that air can enter noiselessly and at a low airflow velocity in occupied zones. For a high level of ventilation comfort, the aerodynamically profiled air control blades rapidly slow down the air flow of the mixed air.

TROX produces the swirl element behind the cover in high-quality plastic, which – unlike metal – permits deformation of the air control blades to optimise flow. The extract air is dissipated by a second row of XARTO diffusers. This creates a symmetrical ceiling pattern as extract grilles are not required.

Building owner: Diocese of Osnabrück
Architecture: PBR Planungsbüro Rohling AG Architects and engineers
Diocese Building & Systems Manager: Jens Hawighorst
HVAC contractor: Voss Gebäudetechnik
Construction cost: €7.5 million

Fire protection systems in schools must meet high standards in terms of sensitivity and safety.

The Marianum Gymnasium Secondary School is attended by over a thousand students – so its safety systems need to be 100% reliable. In this school, the intelligent control and monitoring system TROXNETCOM combines fire protection and smoke control dampers, smoke alarms and duct smoke detectors to create an exceptionally reliable system. With TROXNETCOM, these components continually exchange information. The system status is monitored and analysed on an ongoing basis, ensuring complete safety. In the event of a fire, the system also acts to prevent smoke from escaping via the ducts by controlling the relevant fire dampers and smoke control dampers.

X-CUBE AHU with unique TROX integrated control technology.

Everything from a single source. Service included.

Jens Hawighorst, responsible for planning the system on behalf of the Diocese, was looking for a complete solution: 'Having too many interfaces reduces efficiency. Components from different sources may not be perfectly compatible, or may be difficult to connect to our building control technologies. This is why we opted for a solution from a single source: To minimise the number of interfaces and the work involved in planning and co-ordinating all of the different components. Although the costs of the individual components were a little higher, the overall cost was significantly lower as we had fewer interface issues to contend with'.

Support on site.

To successfully automate a system, you need specific expertise in system parameterisation and monitoring. Roland Becker, the project manager responsible for the measurement and control technology, was on site in Meppen when the system was commissioned, to give everything one final check. Working with the assigned electrician, he checked all the functions of the AHU. The pair analysed error messages and corrected problems such as faulty wiring. The TROX service team know AHU components inside and out: They create intelligent networks and on-site support for measurement and control technology, offering services that extend far beyond the traditional remit of a HVAC provider.

Conclusion:

Jens Hawighorst believes he made the right decision: 'I spent much less time on the construction site, because everything was coming from a single source. The AHU is incredibly efficient and reliable. The innovative control system keeps me updated on the relevant ventilation parameters and reports any irregularities. The monitoring function allows me to analyse the efficiency and effectiveness of the system and correct specific parameters where necessary. The support we were given on site was fantastic'.

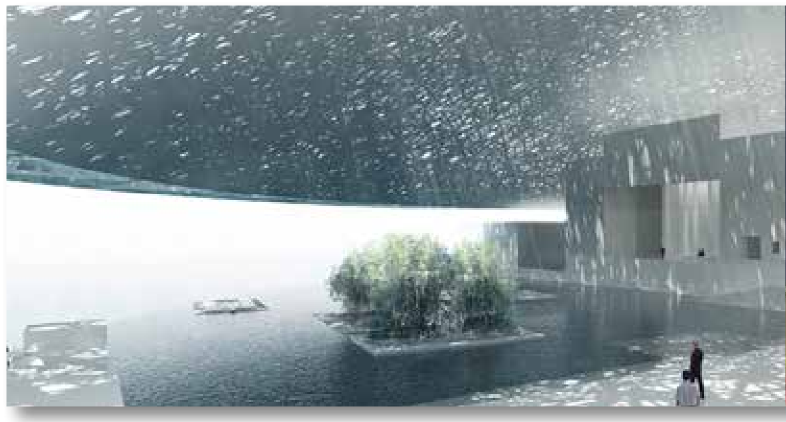
International IAQ.

In office buildings, it boosts performance; in hospitals, it accelerates healing and in schools, it promotes learning. In museums, it protects works of art; in shopping centres, it encourages spending, and in all buildings, it reduces the risk of infection and allergies: Good room air quality, achieved through fine-tuned room air distribution systems, is important in all areas of day-to-day life. TROX has provided products and systems to many prestigious projects all over the world. Just a few of these projects are listed below.

Castellana 77 office and apartment complex, Madrid, Spain: More than 5000 induction units

Torre Banco Macro Buenos Aires, Argentina: X-CUBE AHUs, diffusers, chilled beams

Medisch Spectrum Twente (MST) Enschede, The Netherlands: X-CUBE AHUs, fire dampers, diffusers



Museum Louvre, Abu Dhabi: Passive chilled beams

ÖAMTC mobility centre, Vienna, Austria: Diffusers, control untis, sound attenuators, fire and smoke protection systems

Air cleanliness. New standards to combat life-threatening air pollution.

Particulate Matter (PM) is a mixture of solid and liquid particles with a diameter of up to 10 µm (PM10). Depending on the size of the particles, the health effects of particulate matter can range from irritation and inflammation of the mucous membranes to lung damage and increased build-up of plaque in the blood vessels, which can result in arteriosclerosis. The latest statistics indicate that around the world, approximately 8 million people a year die from the effects of air pollution. This figure could double by 2050.

New filter standard: ISO 16890

The standard testing procedure for large and fine dust filters has changed: Filter performance is now no longer assessed based solely on a laboratory test method, but instead based on real application conditions. Previously, in accordance with EN 779, a synthetic aerosol was used for testing, with a standard particle size of 0.4 µm. Now, the new ISO 16890 standard is based on a range of particle fractions, and tests are conducted using DEHS and KCl test aerosols. Filters are divided into four groups:

- **ISO Coarse** (rated containment capacity against ISO A2 dust)
- **ISO PM10:** Fine dust particles ≤ 10 µm
- **ISO PM2.5:** Fine dust particles ≤ 2.5 µm
- **ISO PM1:** Fine dust particles ≤ 1 µm

Filter performance is now measured with three different particle fractions (PM1, PM2.5, PM10). This test scenario allows the tester to examine the local fine dust pollution more closely (based on data from official measuring stations, for example) and to select a filter that is appropriate for the quality of the supply air.

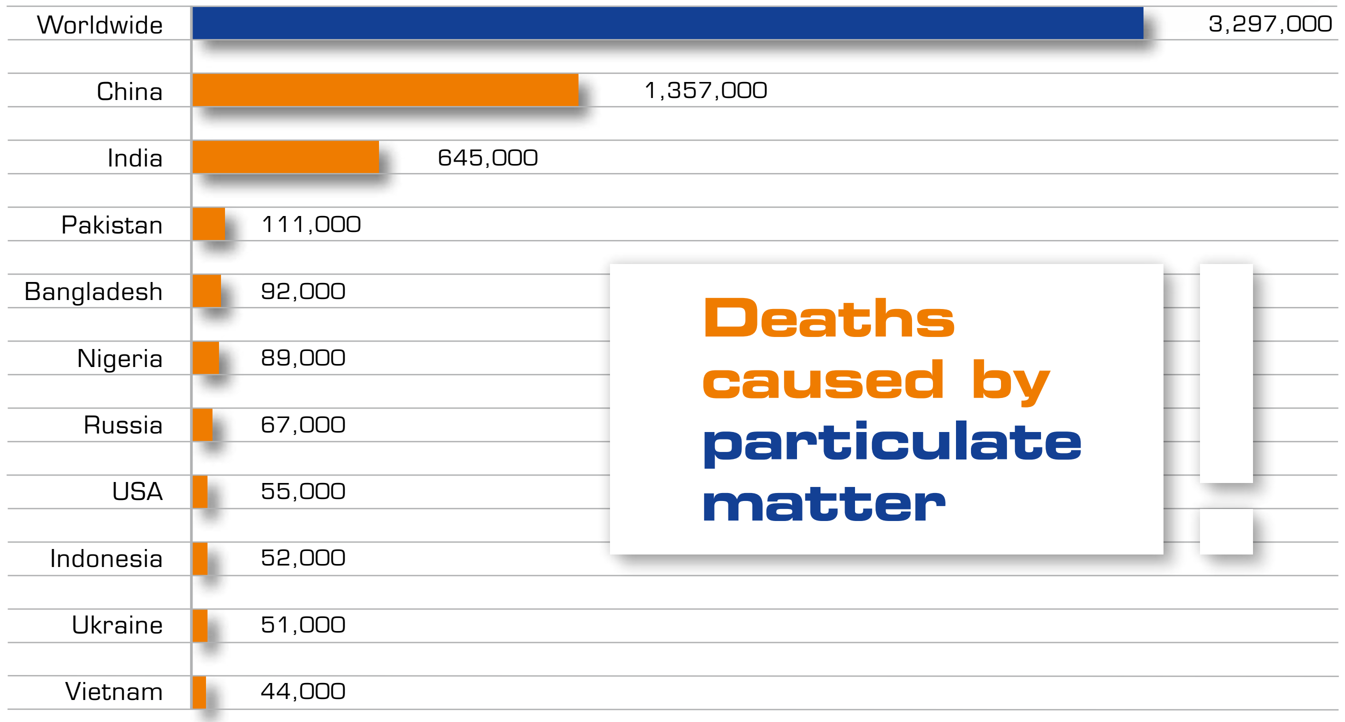
Alongside the filter performance, another important aspect to consider is the energy performance of the filter in day-to-day use. Find out more in our feature on the following pages.

New series of standards: EN 16798*.

Part 3 of the new European standard defines guidelines for air handling units to ensure a comfortable and healthy indoor climate in non-residential buildings throughout the year, while keeping installation and operating costs below an acceptable threshold. EN 16798 Part 3 reuses a great deal of the content of the previous standard EN 13779, but also contains new requirements for AHUs and system technology, relating to aspects such as air filters, heat recovery systems and supply air quality (previously room air quality).

The 15 countries with the highest numbers of deaths associated with particulate matter.

How many people may have died due to factors related to air pollution in 2010?
This data is based on model calculations.



Source: Lelleveld et al., Nature, 2015

Differences	EN 779:2012	ISO 16890
Reference particle size for classification	• 0.4 µm	• 0.3 to 1 µm (PM1) • 0.3 to 2.5 µm (PM2.5) • 0.3 to 10 µm (PM10)
Test aerosol	• DEHS (Di-Ethyl-Hexyl-Sebacat)	• DEHS for 0.3 to 1 µm • KCl (potassium chloride) for 2.5 µm and 10 µm
Electrostatic discharge with IPA (isopropanol)	• Media sample in immersion bath	• Entire filter conditioned with IPA vapour
Efficiency of discharged filter	• Comparison of sample and filter	• Average efficiency of treated and untreated filters
Dust load for classification	• Incremental dust feed	• Classification without dust feed
Test dust for ISO Coarse and energy efficiency	• ASHRAE	• ISO fine
Dust feed	• 70 mg/m³	• 140 mg/m³
Test final differential pressure	• G1, G2, G3, G4 = 450 Pa • M5, M6, F7, F8, F9 = 450 Pa	• PM 10 < 50% = 200 Pa • PM 10 ≥ 50% = 200 Pa
Classification	• G1 to G4 • M5 to M6 • F7 to F9	• ISO coarse • ISO ePM10 • ISO ePM2.5 • ISO ePM1

The outdoor air (ODA) quality requirements have also been redefined. The categories ODA 1 to ODA 3 must now be determined based on loading with O-zone, NO_2, SO_2 and PM10, in accordance with the revised regulations published by the WHO in 2005 (superseding 1999 version). These categories play an important part in determining which air filter should be fitted in the AHU.

The definition of supply air (SUP) quality, divided into five categories, has also been added to the standard.

Air filter requirements

SUP 1 = very low concentration of dust and/or gases
SUP 2 = low concentration
SUP 3 = moderate concentration
SUP 4 = high concentration
SUP 5 = very high concentration

The changes made include the redefinition of the ventilation rates per person and the requirements for air filters, which are now based on supply air quality SUP (previously IDA and ODA). Some of the filter qualities have been amended, and the minimum particle deposition grade for the selected air filter and its associated combinations have been redefined.

Minimum particle deposition grade for the selected air filter and its associated combinations

	SUP 1	SUP 2	SUP 3	SUP 4	SUP 5
ODA 1	M5/F7	F7	F7	F7	
	88 %	80 %	80 %	80 %	k.A.
ODA 2	F7/F7	M5/F7	F7	F7	G3/M5
	96 %	88 %	80 %	80 %	60 %
ODA 3	F7/F9	F7/F7	M6/F7	F7	F7
	99 %	96 %	92 %	80 %	80 %

**Standard series EN 16798 replaces a number of separate standards (such as EN 13779, 15239, 15240, 15241, 15242, 15243, 15251) that previously specified the benchmark in ventilation systems.*

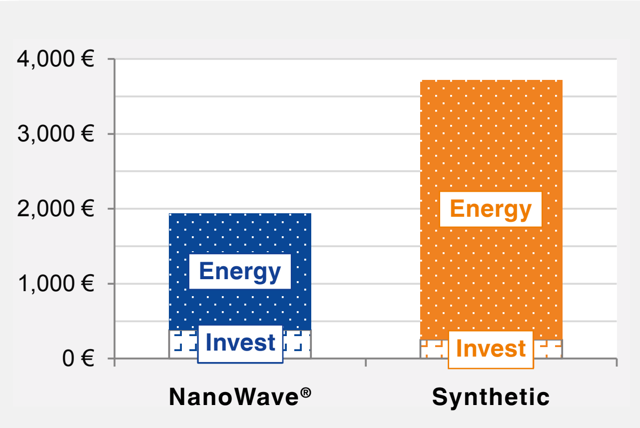
Air filtration.

Effective and highly efficient filter systems filter dust, bacteria and pollen out of the ambient air, ensuring that we can breathe clean air in enclosed indoor spaces. Alongside the factor of system efficiency, the air quality achieved by the air handling unit system is increasingly becoming an important focal point for regulatory bodies across Europe. And the use of high-quality filters pays off – as this case study proves.

Filter efficiency – an investment that pays.

Filters are more than just an investment in room air quality – they're an investment in efficiency, too.

High-quality filters with patented NanoWave® technology feature a wavy profile for a large filter area, delivering an outstanding dust containment performance while keeping differential pressures low. NanoWave® filters are more complex to produce than standard versions – a fact which is reflected in their price tag. However, when the overall costs for industrial applications are compared to those for a standard filter, it is clear that the product is more than worth the additional investment. The innovative filter generates significant energy and cost savings.



Cost comparison: primary energy consumption and cost of acquisition (investment) for filters

In-situ measurement.

TROX identified a production plant with two comparable AHUs (plant A and plant B) to perform differential pressure testing in parallel, real-time operation. One of the systems was fitted with standard synthetic filters, while the other was equipped with energy-efficient NanoWave® filters. The differential pressures in each system were measured over the course of a year. The test period was selected to be fully representative of all seasons and weather conditions.

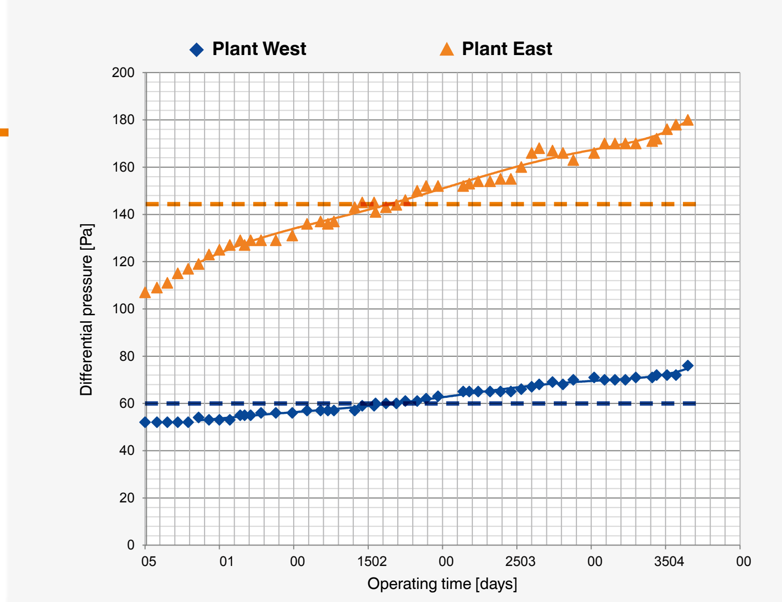
The filter as an efficiency factor.

Fans in air handling units (AHU) require electrical energy, not least to overcome the flow resistance of integrated particulate air filters. The less air resistance that AHU components, such as filters, put up against the air flow, the more energy-efficient the system. As the system ages with continued operation, dust collects inside and the filter slowly becomes clogged. This slowly increases the flow resistance, which in turn means that the fan must contend with ever-greater differential pressures.

The use of energy-efficient filters pays off.

The use of energy-efficient filters reduces the electrical drive energy required by the fans. A lifecycle cost calculation, including an analysis of the overall costs and potential savings, shows how much energy can be saved compared to a standard filter.

The differential pressure of the systems was measured weekly. Based on these measured values, a differential pressure curve was drawn up for the system over the measurement period; the average differential pressure during this time was taken as the starting point for calculating energy consumption.



Good operating performance and good differential pressure curve, with a slow increase of just 24 Pa absolute on the bottom (blue) curve. The orange differential pressure curve reflects a significantly worse energy performance and indicates an absolute pressure increase of 73 Pa, which is three times higher than the bottom figure. The dotted lines show the average differential pressure over the entire measuring period.

These graphs show that the average differential pressure for the NanoWave® pocket filter, at around 62 Pa, is around 58% lower than that of the synthetic pocket filter, which came in at around 147 Pa.

The superior energy profile of the NanoWave® medium – and the significantly more energy-efficient performance of the entire system in which the filter is deployed – is immediately clear. But how does this improved performance affect the overall cost if the initial cost of the investment is also taken into account?

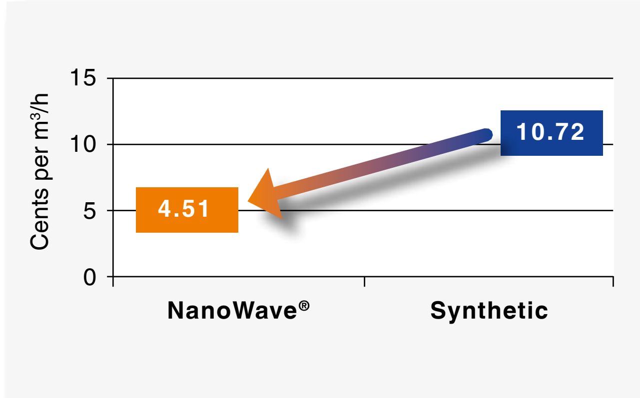
Calculating energy consumption and energy costs.

The energy consumption of both systems can be calculated based on the fan volume flow rate, its efficiency (50%), the number of operating hours (8760 h) and the average differential pressure (61.8 Pa and 146.9 Pa). To compare the two systems, the energy consumption in kWh/a is calculated for the specific operating volume flows (34,400 and 32,300 m³/h) and applied as a specific value in cents per m³ of processed air per year.

Energy costs: With the NanoWave® energy-efficient filter installed in system A, the energy costs per cubic metre volume flow were reduced by around 58% compared to synthetic filters (from 10.72 to 4.51 cents per m³/h and year).

Overall cost calculation: In the overall cost calculation, the investment and material costs were added to the energy costs. As the number of filters installed and their usage durations were identical, labour costs were not taken into account.

Amortisation: The NanoWave® filter, which initially costs around 50% more to purchase, pays for itself in less than a month, and significantly reduces overall costs thanks to its improved filter resistance and more level differential pressure curve. The energy-efficient NanoWave® filter reduces the overall costs by around 51% compared to the synthetic standard version.



NanoWave® reduces energy costs per cubic metre by almost 60%.

Online LCC calculator.

TROX has developed a Life Cycle Cost (LCC) tool in order to calculate the economic efficiency of fine dust filters. Customers are able to use their system's volume flow rate data to choose the filter that will be the most economical and energy-efficient for their application. The system also offers more detailed calculations that take individual usage data into account.

Breathing in space.

How do astronauts on the ISS get the air they need to survive? Does the space station have an air conditioning system? Read on to find out the answers to these and other fascinating questions in our report on air in extreme environments.

Life-maintaining systems.

High up in space and down in the depths of the ocean, we rely on technology to keep us alive in environments that are not naturally able to sustain human life. These technologies are known as life-maintaining systems. On earth, the biosphere provides everything that living creatures need to survive.

In addition to providing food, the main functions of life-maintaining systems include supplying air for respiration and controlling the climate.

Indoor air on the ISS.

For resting or gentle activity, astronauts need at least 800 g of oxygen a day – or more if they are working a little harder or in more challenging conditions. On previous journeys into space, astronauts took oxygen tanks on board – which was sufficient in the early days of space travel, when they were only away from earth for a few days. On space stations such as the ISS, astronauts now spend far longer up in space, so oxygen generation systems have been developed to meet these needs.

On board, levels of hazardous substances in the air must be as low as possible, and the air quality must meet specific parameters. On board the ISS, an overall pressure of 97.9 to 102.7 kPa, an oxygen partial pressure of 19.5 to 23.1 kPa, a nitrogen partial pressure of below 80 kPa and a carbon dioxide partial pressure below 1 kPa is considered acceptable.

The air temperature on board can be adjusted between 18.3 and 26.7 °C. Thanks to the air conditioning technology, the ISS benefits from a humidity level of between 25 and 75% and constant air movement of between 0.05 and 1.0 m/s to prevent microbial growth, mould and dry air (which is associated with an increased risk of sparking).

Generally, oxygen is produced through water electrolysis. Additional oxygen can be regenerated from carbon dioxide using the Sabatier process.

Submarines rely on similar processes. When these vessels come up to the surface, they 'snorkel' in air to refresh the oxygen on board. In the ARA San Juan, which went missing with 44 people on board, the oxygen reserves were sufficient to last up to seven days.

Biological life-maintaining systems.

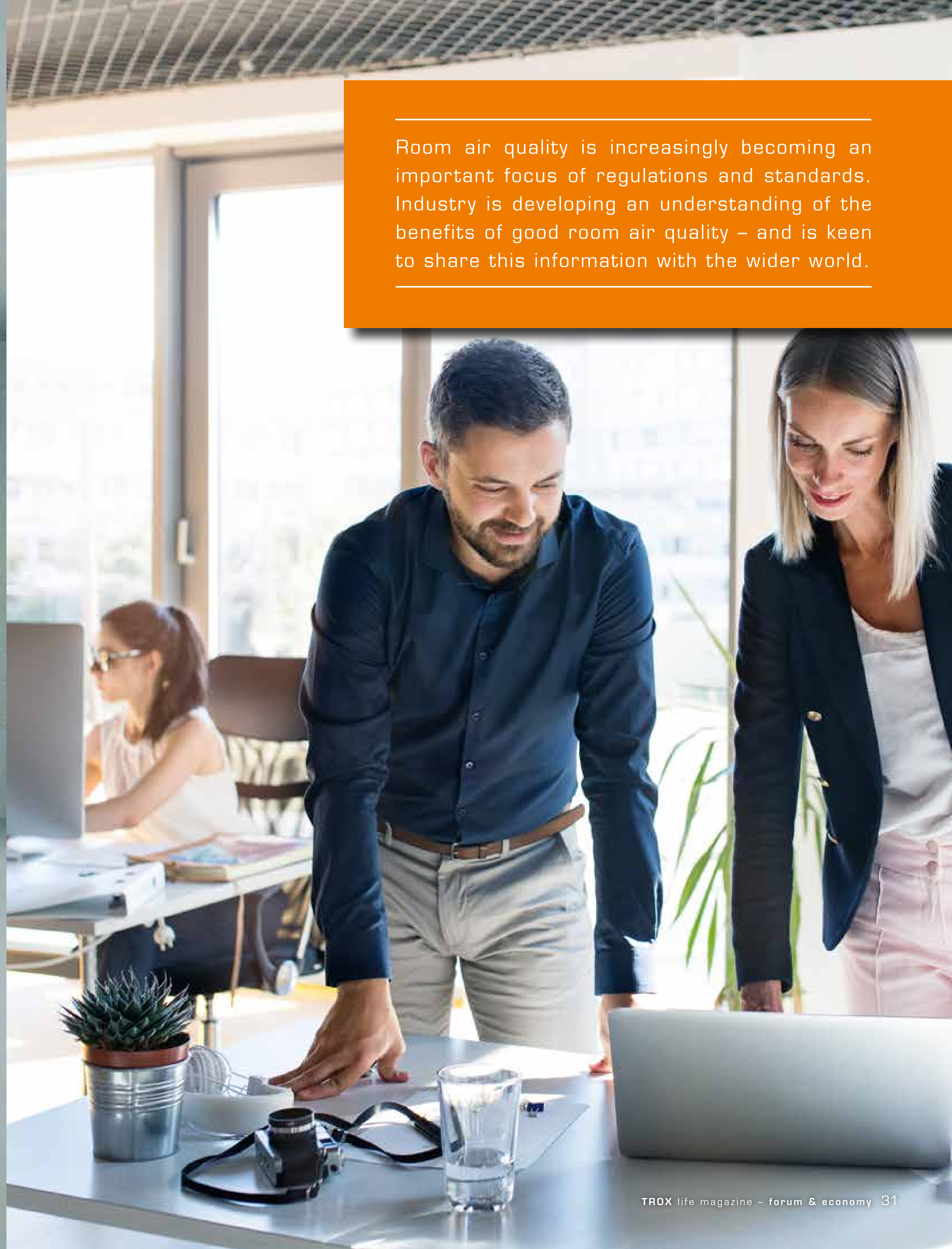
Researchers at the Institute of Space Systems at the University of Stuttgart are aiming to revolutionise the future of space travel – with algae. The role of these micro-organisms is twofold: They convert the carbon dioxide breathed out by the astronauts into oxygen, and can also be eaten.

The algae will be grown in a small photobioreactor. Carbon dioxide will enter the water in the container through gas-permeable membranes. The oxygen generated during photosynthesis exits the system and travels into the indoor air in the station via these same membranes.

'Thanks to the high protein content of the algae biomass, it could account for around 30 percent of the astronaut's diet', explains Alexander Henn from the German Aerospace Centre (DLR – Deutsches Zentrum für Luft- und Raumfahrt).

The first photobioreactor is set to be launched into space in 2018. The algae will produce oxygen for between 150 and 180 days and will reproduce on board the ISS.

Room air quality as an economic factor.



Room air quality is increasingly becoming an important focus of regulations and standards. Industry is developing an understanding of the benefits of good room air quality – and is keen to share this information with the wider world.

EPBD: Room air quality and efficiency take centre stage.

The Energy Performance of Buildings Directive (EPBD) published by the EU Commission is one of the most important European directives affecting the building and building technology sectors.

In October 2017, the proposal put forward by the Committee on Industry, Research and Energy (ITRE) regarding the revision of the Energy Performance of Buildings Directive was debated in the European Parliament. The final version of the EPBD will be binding on all EU states from 2021. In Germany, the directive will be implemented via the Energy Saving Ordinance (EnEV – Energieeinsparverordnung). Alongside energy efficiency, the EPBD places great importance on room air quality.

The revised EPBD includes specifications and measures to boost the energy efficiency of new (virtually zero-energy) and existing buildings. The building shell, building technology and efficiency must all be tested for compliance with the required standard, and an energy certificate must be obtained for the building.

By 31 December 2020, EU member states must 'ensure that all new buildings meet low-energy building standards; all new buildings occupied by public authorities and built after 31 December 2018 must also meet this standard. The member states must draw up their own national plans to increase the number of low-energy buildings'.

As part of the new standard, the building owner must be able to provide a numerical indicator expressing the primary energy consumption of the building in kWh/m² per year. The directive also includes mandatory inspections for heating, ventilation and cooling systems, as well as building automation systems. The inspection requirements for non-residential buildings will now be based on an energy threshold value of > 250 MWh annual primary energy consumption.

Energy-efficient renovation essential.

In the introduction to the draft of the EPBD, the EU stated that the quota of energy-efficient renovations carried out on existing buildings was currently as low as 0.4 to 1.2% across the member states.

Considering that around 75% of all existing buildings are deemed inefficient by modern standards, there is huge potential to reduce energy consumption and greenhouse gas emissions by renovating the energy systems in some of these properties. For this reason, the EU is planning various campaigns, including financial incentives, to significantly boost this percentage and to encourage people to embark on modernisation projects over the next few years. The EPBD also encourages the use of intelligent control technology for building systems, and promotes building automation and building management solutions.

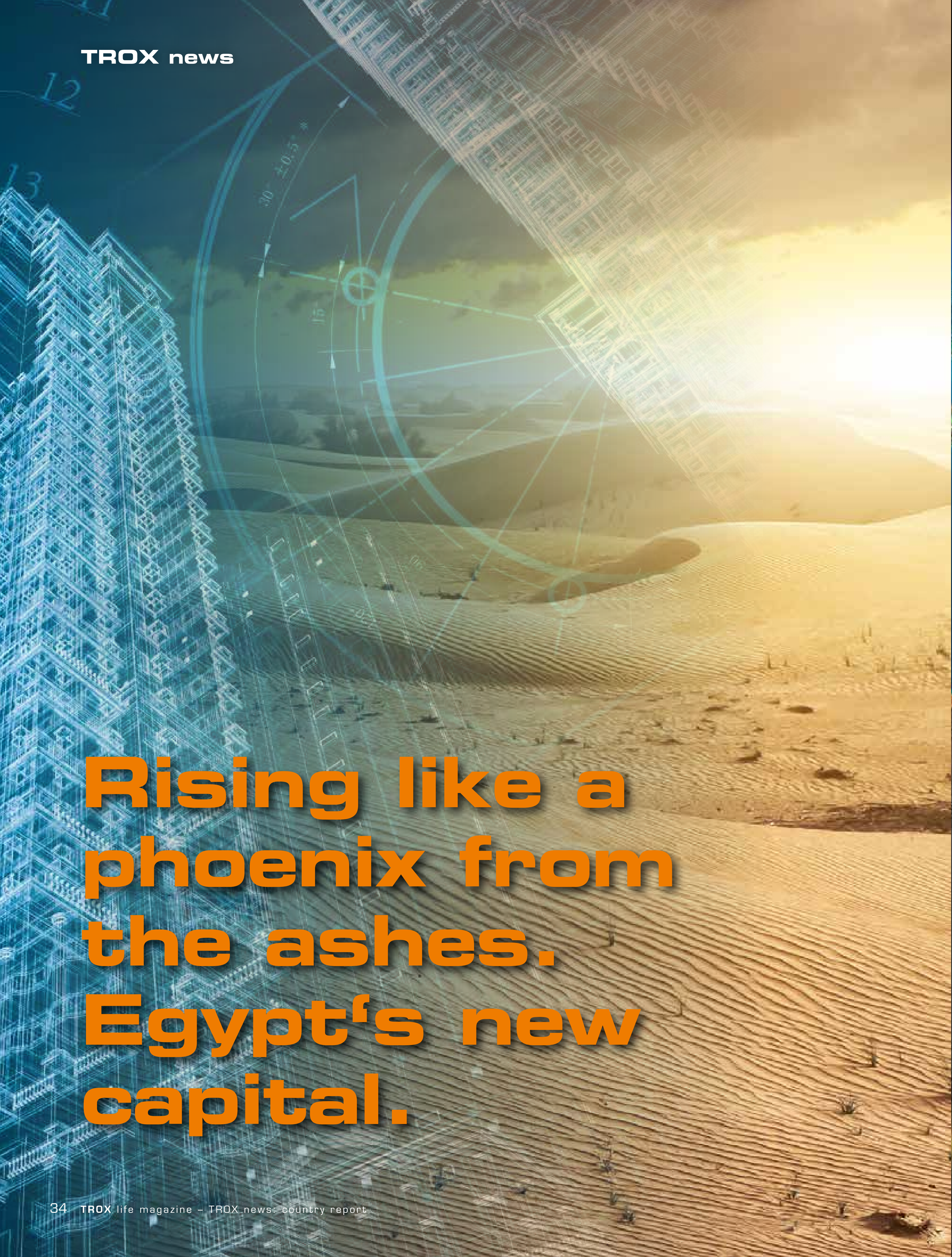
Room air quality: The benefits outweigh the costs.

Thermal comfort and room air quality have also increasingly become a focus of legislators – and the economic benefits are beyond doubt.

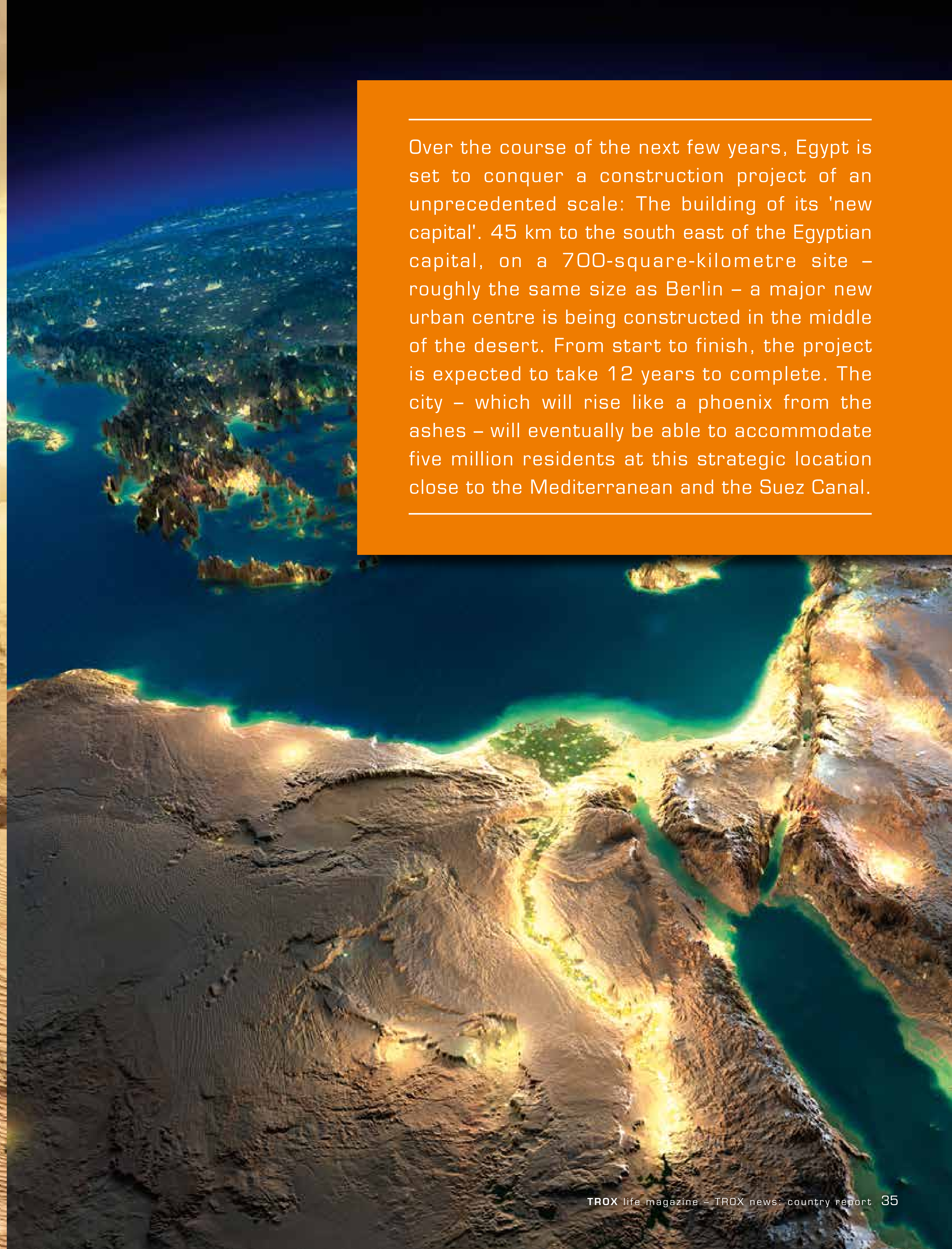
Fisk* was one of the first to demonstrate the economic benefits of high-quality room air.
He reports:

- A 20 to 50% reduction in sick building syndrome, saving between 10 and 100 billion US dollars.
- 8 to 25% fewer asthma-related absences, saving 1 to 4 billion US dollars.
- A 23 to 76% reduction in respiratory diseases, saving 6 to 14 billion US dollars.
- Productivity increases of 0.5 to 5% for office workers, generating gains of 20 to 200 billion US dollars.

**William J. Fisk, 'Health and Productivity Gains from Better Indoor Environments'*



Rising like a phoenix from the ashes. Egypt's new capital.



Over the course of the next few years, Egypt is set to conquer a construction project of an unprecedented scale: The building of its 'new capital'. 45 km to the south east of the Egyptian capital, on a 700-square-kilometre site – roughly the same size as Berlin – a major new urban centre is being constructed in the middle of the desert. From start to finish, the project is expected to take 12 years to complete. The city – which will rise like a phoenix from the ashes – will eventually be able to accommodate five million residents at this strategic location close to the Mediterranean and the Suez Canal.

A presidential palace, ministries, administrative buildings, stock exchanges and banks, hospitals, companies, universities and schools, foreign embassies: At some point in the future, all of this will move to Egypt's new city and transform it into the political and economic centre of the country.

Infrastructure – a major challenge.

Water supply: Canals, fed by the Nile, will supply water to Egypt's future capital; an 'enormous oasis' will be constructed.

Road network: Roads are already in place. Six-lane highways have already been constructed through the desert.

Air and rail travel: Multiple airports and high-speed railway lines are planned.

Energy supply: Siemens is currently building the world's largest gas power plant for Egypt's new capital, plus two further plants at Beni Suef on the banks of the Nile and in Mediterranean Borollos. These plants will provide energy for 45 million people, or half of the Egyptian population. By the end of 2018, the three plants will be producing 14,400 megawatts of power, representing a major upgrade to the country's energy supply network. The plans also include twelve new wind parks, which will generate an additional 2000 megawatts.

Egypt is a key player on the African continent.

With over 94 million residents, Egypt is one of the most densely populated countries and the most successful economy on the African continent. While the United Arab Emirates and Saudi Arabia generate their wealth from oil, Egypt's economy relies on its role as a producer and the strength of its human capital. The country's proximity to the Mediterranean and Red Sea also brings unique geo-strategic advantages.

As climatic conditions in Egypt can be extreme, intelligent, effective and efficient ventilation and air conditioning systems are essential.

TIBA Manzalawi Engineering. New sales partner in Egypt.

TROX has formed a new sales partnership with the TIBA Manzalawi Group, which has its headquarters in Cairo. TIBA is a major player in the HVAC market in Egypt. The company produces and sells air conditioning products under licence. Its ultra-modern production facilities and logistics centre are situated on the outskirts of the Egyptian capital, at the heart of the logistics hub that leads to Alexandria and the Suez Canal, and on to the Mediterranean and Red Sea.

By entering into this promising new sales partnership, TROX will be able to make its mark in Egypt. TIBA – a major player in North Africa – is a well-known air conditioning specialist, and has been contracted to provide a large share of the systems for the new capital.

TIBA has set itself the objective of expanding its portfolio to include ventilation and air conditioning products and systems, aiming to bring AHU technology in Africa up to European standard.

CEO Shady el Manzalawi: 'We want to establish a long-term partnership between TROX and TIBA, and Egypt as a hub, to supply TROX products in Egypt and possibly other markets in Africa and the Middle East'. With TROX Products.

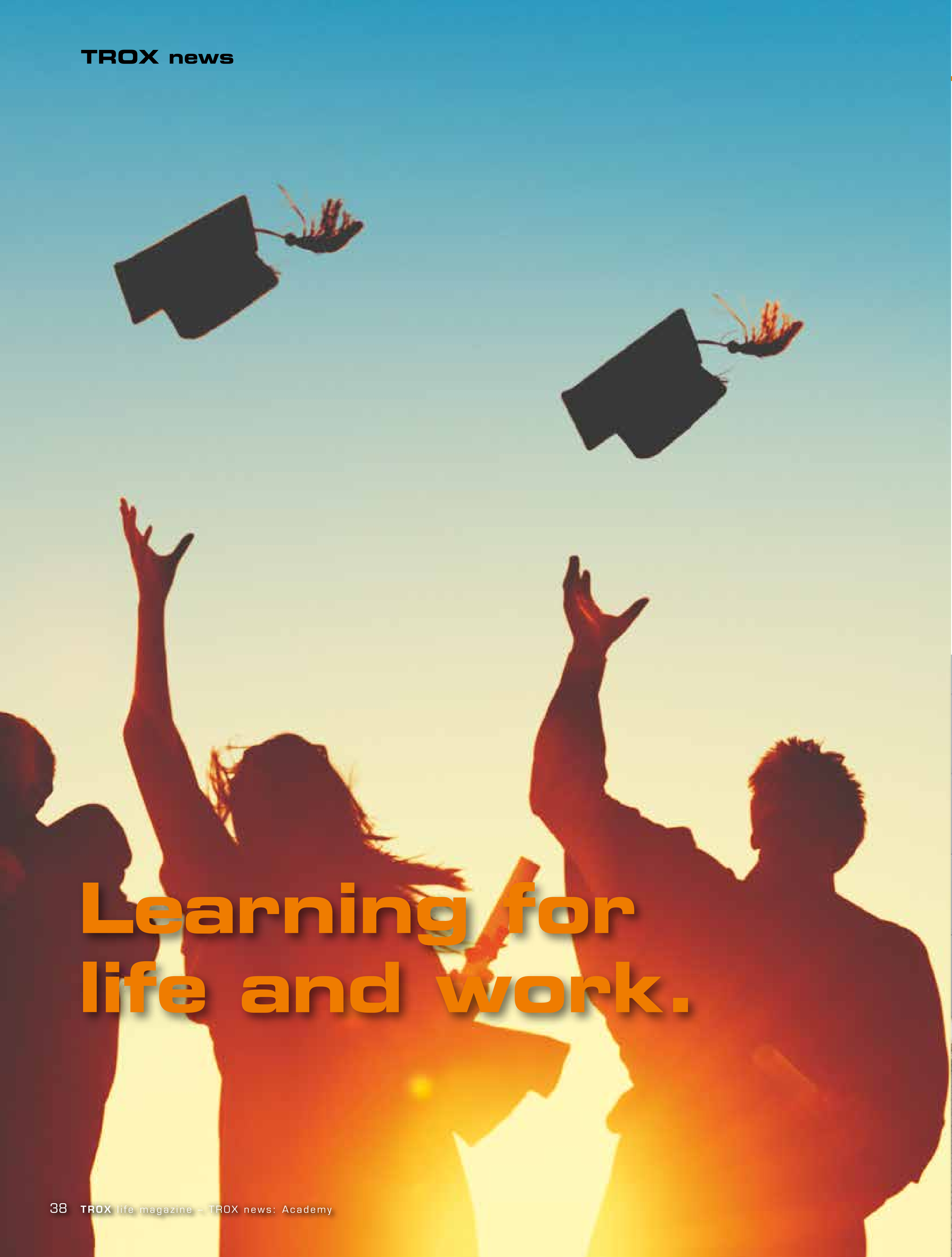
Shady el Manzalawi, CEO, TIBA Manzalawi Engineering

Egypt in figures.

Area: 1,001,449 km²
Population: approximately 94 million
Population growth: over 2%
GDP growth rate: 2%
Investment rate: 14%
Unemployment: 13%

Egypt's vision for 2030.

Population growth: 2%
GDP growth rate: 12%
Investment rate: 30%
Unemployment: 5%



Learning for life and work.

TROX ACADEMY.

Our working lives are becoming increasingly complex. The rapid rise of digitalisation, new technologies and systems-based thinking requires the ventilation and air conditioning sector to develop ever-more specialist knowledge. To ensure that our partners are kept up to date with all the latest developments, we established the TROX ACADEMY which is growing in popularity in our sector: Last year, around 3,000 professionals attended our symposia and seminars in Germany alone. In 2018, the TROX ACADEMY is once again offering a comprehensive programme of further training, covering topics such as:

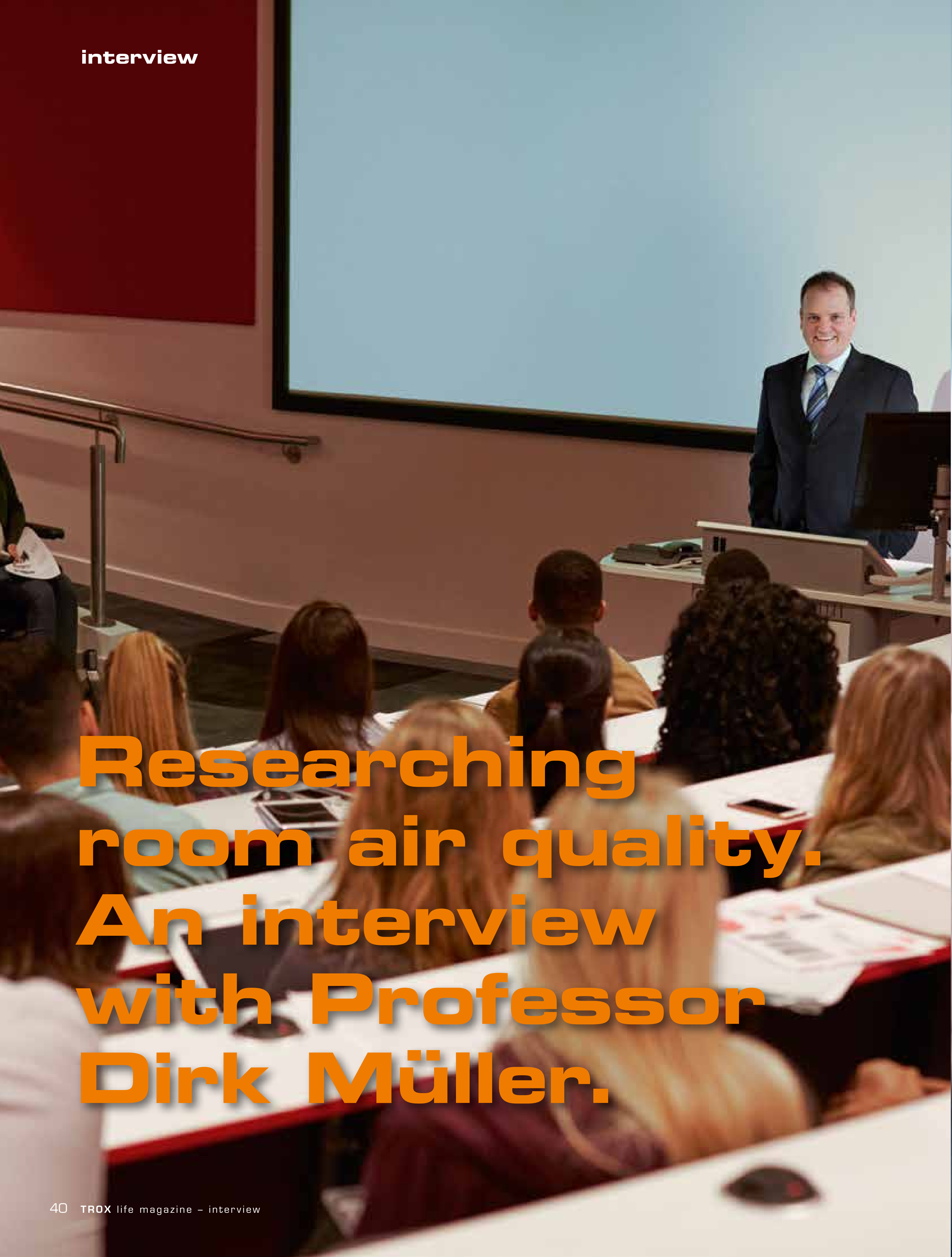
- Fire protection systems
- Smoke extraction systems
- Control systems
- Control technology
- Standards and guidelines
- Design of ventilation and air conditioning systems

At our site in Neukirchen-Vluyn, Germany, our international team of employees receives intensive training and learns about the latest developments and regulations in our sector. We regularly exchange knowledge and experience with colleagues across the globe, and our subsidiaries can access country, audience and project-specific training content and tools – enabling them to compile tailored, country-specific training programmes for their regions.

Sharing knowledge online.

Our webinars are a quick and convenient way to share information on various topics, such as new standards – without either party having to go to great lengths to set up or attend a physical training session. The chat function allows participants to ask questions, which we address at the end of the presentation. Visit our website at www.trox.de/academy for a list of upcoming topics and dates.

www.trox.de/academy



Researching room air quality. An interview with Professor Dirk Müller.

Professor Dirk Müller is the Managing Director of Heinz Trox Wissenschafts gGmbH. In close partnership with Müller's Institute for Energy Efficient Buildings and Indoor Climate at RWTH Aachen University, the company is involved in a number of national, international and interdisciplinary projects to conduct fundamental research on the topic of 'people indoors'.

Professor Müller, would it be accurate to say that the company at which you hold the role of Managing Director, Heinz Trox Wissenschafts gGmbH, has made it its mission to research the 'well-being of people indoors'?

Yes indeed. In this field, there are a lot of open questions that we need to find the answers to.

Is it true that everything has become much more transparent in the age of digitalisation?

Partially. Yes, the digitalisation and networking of ventilation and air conditioning systems transforms them into intelligent systems, which enables us to collect a great deal of data, which we can then analyse and respond to accordingly. However, this is only true of parameters that we can actually measure.

And what does that mean in concrete terms?

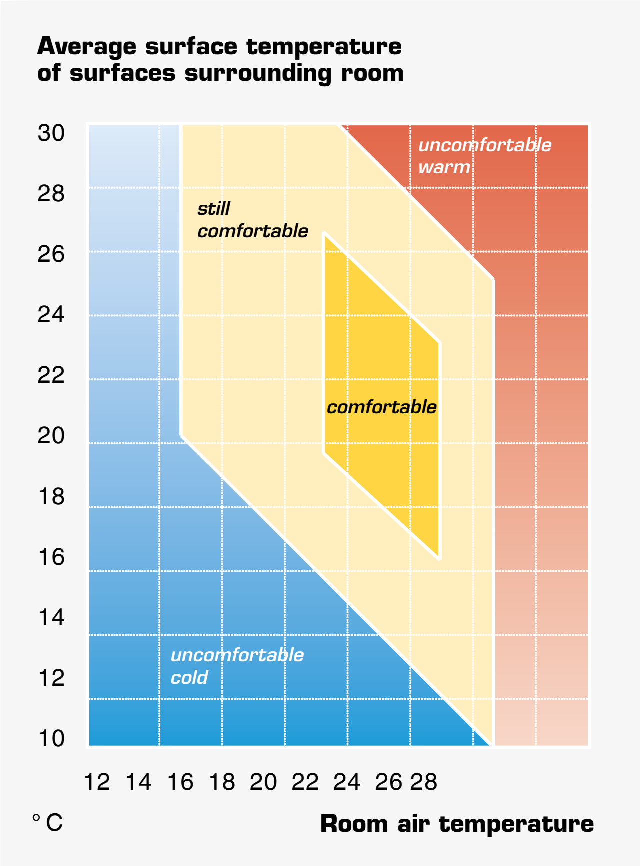
Modern AHUs are kitted out with sensor technology, enabling them to record data on objective criteria such as air temperature, humidity and measurable air pollution. But how comfortable a person feels in a room also depends on a range of other factors, some of which are highly subjective. We can still only measure a small proportion of the parameters that impact on the occupant's well-being. And in many rooms, current systems do not allow us to respond to individual occupant needs at all, or at least not to the extent that we would ideally like. For this reason, we still see dissatisfaction rates of 15 – 20%, even if all of the technology is functioning exactly as it should. There is a lot of scope to make improvements in this area. And then there's the question of how we actually define good room air quality. Should we strive for a completely odour-free environment? Everybody has a different answer to this question.

Could you give us an example?

We've all been in a situation where we've been sitting in a room with other people and while some are complaining that they have cold feet, others feel too hot, and others just want to open the window. Everyone has their own ideas and preferences, so we need to design the buildings of the future to be more flexible.

It's not always possible or desirable to work at a constant room temperature. It's important to understand the acceptable ranges within which room temperature can fluctuate and how certain temperature changes away from or towards the 'ideal' level are perceived by occupants. The aim of our research is to develop a greater understanding of how people experience temperature. There is a great deal of research focusing on thermal comfort in constant temperature conditions, but we conduct trials in transient conditions. Our results are helping us to find out which heating and cooling processes are experienced as comfortable and which are disruptive.

In addition to temperature, humidity is also an important comfort factor. This parameter is easy to measure, but in my opinion, its importance is often underestimated by designers and system owners. Humidity is a critical factor affecting how we experience odours, and it is also directly linked to the risk of infection. If the air is too dry, there is a greater risk of infection being transferred from one person to another – in low humidity conditions, the person's airways are dryer, and there are more small air particles present to transport bacteria. If the humidity level is too high, moisture cannot evaporate away from our skin and the atmosphere will feel hot and stuffy. For these reasons, we strongly recommend that relative humidity is maintained in the region of between 30 and 60%.



Are there any other subjective aspects that affect how we perceive the quality of indoor air?

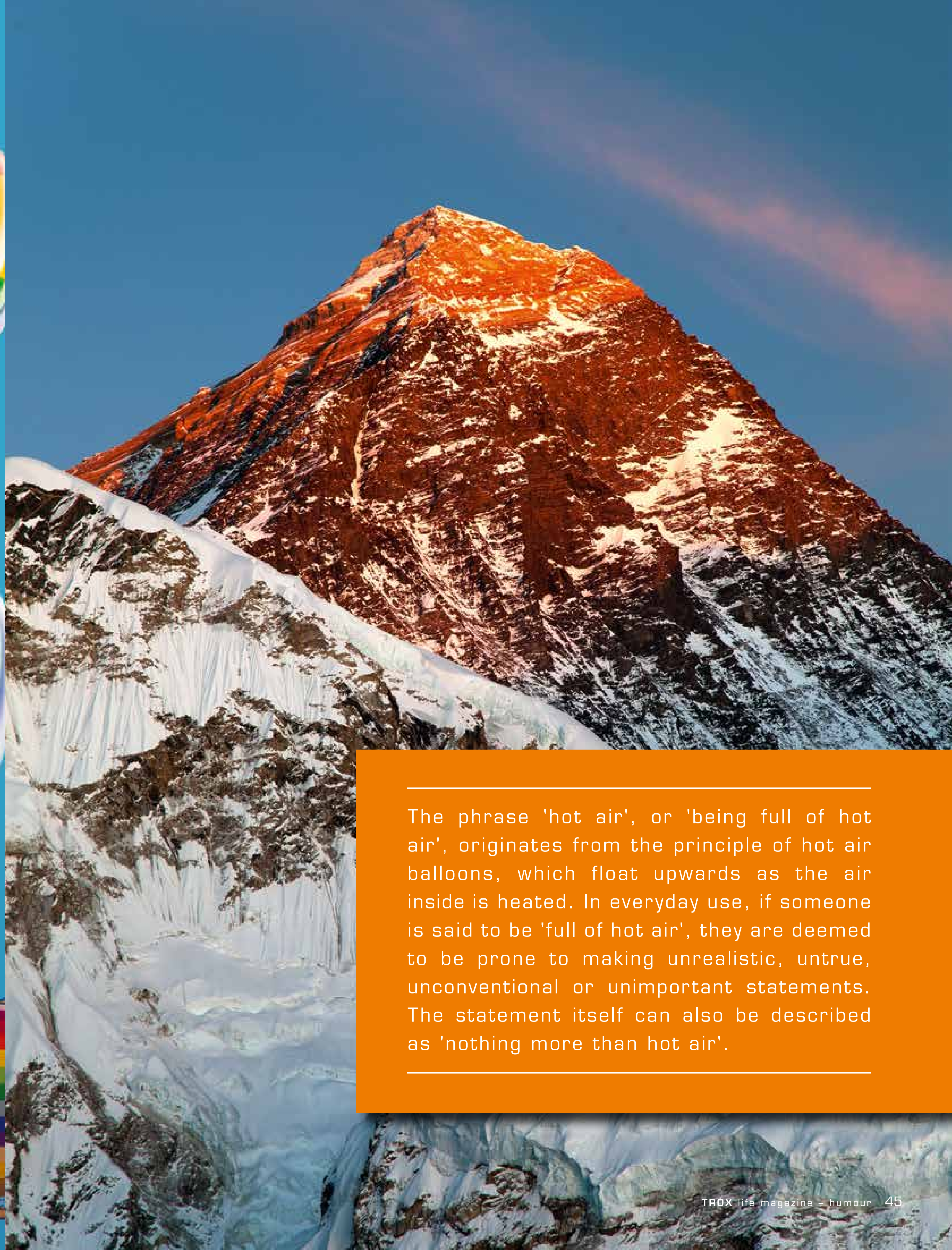
How we perceive odours is a good example: The nose is a highly sensitive organ that science has not been able to artificially replicate. We cannot use a traditional measuring device to evaluate the odour given off by any substance, such as building materials, for example. Even if we can categorise all of the substances present in an air sample, we still cannot predict an odour profile for the sample. A further complicating factor is the fact that substances can overrule or neutralise other substances in our perception of a particular smell. And as we know, perceptions of an odour can vary from person to person. The context is also important: It's fine if a bakery smells of bread. But the same smell would be surprising in a cinema. And ideally, no building should smell of smoke. It's also interesting that some people simply don't have a very highly developed sense of smell.

So room air quality is still a rather extensive field of research?

Indeed. All active researchers supported either directly or indirectly by Heinz Trox Wissenschafts gGmbH are incredibly grateful for the fact that this unique form of support is available to them. And as we all use rooms and indoor spaces all the time, I am sure that we will all see the long-term benefits of the research conducted by Heinz Trox Wissenschafts gGmbH.

Professor Müller, thank you for your time.

Hot air.



The phrase 'hot air', or 'being full of hot air', originates from the principle of hot air balloons, which float upwards as the air inside is heated. In everyday use, if someone is said to be 'full of hot air', they are deemed to be prone to making unrealistic, untrue, unconventional or unimportant statements. The statement itself can also be described as 'nothing more than hot air'.

Air-based cures.

Did you know that laughter widens the blood vessels and improves blood flow? Extended periods of uncontrollable laughter raise the heart rate and breathing rate. This means that we take in more oxygen and breathe out more carbon dioxide. Experts can use these values to determine how much energy we burn by laughing. So you heard it here first: laughing burns calories. Remember that next time you're considering a diet!

In spite of the fact that the air actually contains plenty of oxygen to meet our needs, there are various lotions and potions available that claim to oxygenate your skin. Or if you really want to be on trend, you can visit an 'oxygen bar', where you can drink or inhale highly concentrated oxygen concoctions. A 30-minute air treatment in which you breathe in a 94% oxygen mixture through a mask is said to work wonders: the treatment promises a range of benefits, from boosting your sex life to improving gum health. But before you part with your money, proceed with caution: The air we breathe contains 21% oxygen, and we only use 4% of it, so nature already more than meets our needs. If this wasn't the case, we would be unable to survive.

Another trendy product that we're increasingly seeing on the shelves is oxygen-enriched mineral water. These bottles contain 15 to 25 times more O_2 than normal drinking water, equivalent to around five breaths' worth of oxygen. It has been scientifically proven that oxygen can be absorbed via the stomach and intestinal tract. However, even if our digestive system managed to absorb all the oxygen in a litre of O_2-enriched water, we would only take on board an extra 24 to 226 milligrams of oxygen, compared to the 500 grams we absorb every hour by simply breathing. Now that really is nothing more than hot air – and the body will find a way to get rid of the surplus.

Hot air.

On 1 April 2005, German newspaper the Tagespiegel published an article that was all hot air under the headline 'Canned Berlin air – a popular souvenir for tourists from all over the world'. According to the article, the EU was seeking to outlaw the sale of the air, if the Senate was unable to bring down the levels of dangerous particulate emissions caused by diesel engines in the city. The article was based on a letter purportedly sent to the environmental department at the Senate from the offices of EU Environment Commissioner Stavros Dimas. The letter indicated that, in a random sample, more than 35 percent of the tested cans were found to contain excessively high concentrations of fine particulate matter. If the authorities were unsuccessful in finding a long-term solution to clean up Berlin's air, the product would have to be withdrawn from sale and remaining stock disposed of by experts.

The 'air in cans' debacle may have been nothing more than hot air – but it was at least entertaining.

Hot air.

Longest held breath: The longest time anyone has ever spent underwater without coming up for air is 22 minutes and 30 seconds.

Thin air: On Mount Everest, at an altitude of 8,850 metres, the oxygen concentration in the air drops to a third of its normal level.

Walking in the air: Swiss tightrope walker Freddy Nock walked a 347-metre tightrope at an altitude of 3,500 metres in the Bernina Range in the Alps – without any kind of safety harness.

Falling through the air: The world record for the highest ever parachute jump is held by American Alan Eustace, who jumped through the stratosphere from a height of 41 km. Eustace jump broke the sound barrier, achieving a top speed of 1,322.9 km/h during his descent back down to earth.

Airborne survivor: When his parachute failed, British parachute jumper Michael Holmes plunged back down to earth at 193 km/h per hour, from a height of 3,600 metres. He landed in a bush, hitting the ground at 130 km/h – and survived.

Airless diving record: 37-year-old Herbert Nitsch holds the world record in freediving. In four minutes and six seconds, he reached a depth of 185 metres and travelled back up to the surface – without an oxygen tank.

TROX® TECHNIK
The art of handling air

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