February 2014

European Association for sustainable Laboratories

EGNATON Notes plus

- Hints and Strategies for the Stakeholders in the Laboratory Industry
- Topics to consider for sustainable Lab Design
- Particular sustainable Solutions

EGNATON

Premiere

I welcome all readers of the first edition of our EGNATON Notes plus Journal, which we are now issuing in the fourth year of our existence as a club.

EGNATON is not an interest group, EGNATON represents all stakeholders in the laboratory industry. EGNATON is an association with a European dimension, which is also reflected in the members' profile.

Meanwhile, fortunately, members from a total of 15 countries have been included. Our members come from following areas:

- Architects and planners
- Installers and manufacturers of laboratories
- Private and public operators
- Associations and interest groups around the industry

Looking back – how it all began

Every beginning is difficult. When we started with only a handful of members in November 2009, it was a journey into the unknown. The objective of EGNATON is to strengthen the sustainability of laboratories and their environment and to bring them forward. We rely on our know-how, which is backed by the extensive knowledge of our club members and experts.

EGNATON provides the basic conditions that are necessary to allow our knowledgeable experts in interdisciplinary working groups the research the subject of sustainability.

Various working groups within EGNATON are involved in the following topics:

- Energy consumption and lab room ventilation
- Architecture and engineering
- Working conditions
- Use of materials
- Life cycle costs
- Product certification and EGNATON CERT

The expert team works voluntarily and explores interdisciplinary topics that are of interest to our members. The results of the working groups are presented to the public at conferences or in the future also in the "EGNATON Notes plus". It's important to us that the results are neutral and open to the public. One example to be mentioned at this point is the EGNATON Factor, which was developed and implemented in the working group energy consumption by Peter Dockx. This EGNATON Factor allows the energy efficiency of a laboratory building to be clearly identified and thus the results optimized.

New Developments and future Perspectives

EGNATON CERT

Experts from EGNATON have been working for years in working parties with the DGNB and the BNB certification. The certification of buildings according to DGNB or BNB or even LEEDS or BREAM need statements and specifications of building materials used. These include laboratory facilities fume cupboards, MSC or major appliances such as washing machines and autoclaves. EGNATON now has used several working groups in order to define the most important product groups, the PCR "product category rules". Here we work together with the IBU Institute with the objective to develop this PCR dialog. The goal is ultimately to define globally valid PCR. Furthermore, we will create EPD "Environmental Product Declarations" for the developed categories based on the PCR. EGNATON works in cooperation with the German Ministry of Construction and research institutes such as SGS. In a first transitional period, these EPD will represent common values for all club members. After a period of consolidation, the members can create proprietary EPD.

These EPD form the basis for a separate EGNATON certification of the EGNATON CERT seal, which EGNATON awards for especially sustainable products.

In this regard we are currently working on the following product groups:

- Laboratory fume cupboards and ventilated units
- Autoclaves
- Washing machines
- Freezers
- Chillers
- Laboratory furniture
- Safety cabinets
- Laboratory taps

So far, all expenses have been borne by EGNATON and its members. EGNATON, however, has submitted a funding application to the Federal Ministery, a grant would accelerate our project significantly.

University Working Groups

For members of universities EGNATON has specially established a special working group to ensure that exchanges of information and experience is backed up in the university sector.

Conclusion

EGNATON is an association that wishes to share his ideas and knowledge with the public. For this reason, we are releasing the journal "EGNATON Notes plus" in order to be able to convey not only to our members, but also to a wider public the latest knowledge and information on the subject of sustainability in laboratories. This is the challenge we would like to introduce at the international level and I hope that we have chosen the right information for you. With this in mind, I hope you will enjoy reading this.

An association such as EGNATON is always driven and inspired by its members and their input. If you have found this reading and it's content to be worthwhile and are interested in contributing or becoming a member, please contact us via our website www.egnaton.com. We look forward to hearing from you.

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Contents

Premiere 2

Contents 4

4th Annual Conference Milano 5

Certification of Sustainability 6

Laboratories in which People can perform at their Best
The Laboratory as the Workplace of the People 9

Sustainable Instruction in Occupational Safety
Optimizing Occupational Safety with Blended Learning 14

Good Ventilation Practice in Laboratories 16

Extract Air of what Kind in Laboratories? 18

Sustainable Air Ventilation using an Example of one of the most contemporary Ventilation and Service Systems for large Lab Areas 20

Energy-efficient and flexible Laboratory Building with native BACnet/IP 24

Energy Consumption with Focus on Sustainability 27

Temperature of Intake Air
A brief Investigation on the Influence of the Positioning of the Air Intake 30

The Quest for an appropriate Project Management Approach for sustainable Laboratory Buildings of the 21st Century 33

Considerations to be taken to reduce the negative of Manufacturing Laboratory Equipment impact on Sustainability 35

The Importance of Safety Cabinets for sustainable Laboratory Work 39

Sustainability in Animal Laboratories – A Wish or Reality? 44

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Mottoe: **Focus on Humans in Labs**

May 27th 2014	Moderator **Egbert Dittrich**
May 28th 2014	Moderator **Paul Lodewijckx**

Workshop:

Dr. Peter Neurieder, Dr. Thomas Brock	Safety concepts and risk assessments
Key presentation: Dr. Albrecht Blob	Sustainability and Work Safety – Contradiction or Matter of Course

Conference:

K. Kreuzer	Welcome
Prof. Dr. Silvio Garattini, President of Mario Negri	Welcome
Priv. Doz. Dr. Wolf v. Tümpling, Environment Research Center Halle Leipzig	Aspects of quality assurance processes in analytical laboratories and beyond
Dr. Ing. Ottavio Zirilli	How to integrate users into planning processes – Wishes and Reality
Prof. Dr. Massimo Corradi, Parma	LAA
Prof. Dr. Jürgen Einax	Chemometrics – Essential tool in the analytical lab
Dr. Cedric Herry, Erlab	Optimization of the Energy Consumption of Laboratories based on Risk Assessment
Alaedin Seyedi, Bygnigsstyrelsen Klima-, Energi og Bygningsministeriet Denmark	How are User Needs considered in Public Buildings
Mario Don Porto Carero, J & J	Behavior of occupants – Teaching and Training
Dr. Vito D´ Incognito	What the user can do to achieve sustainability – hints to work sustainable
Prof. Dr. Gunter Henn, Henn Architekten	Work Flow and Architecture
Prof. Dr. Ulrike Felt, Uni Vienna	Rooms for Researchers
Gordon Sharp, Aircuity	Making Lab Buildings Smarter for Increased Safety and Energy Efficiency
Dr. Volker Krieger, Fact – BIM	A conclusive and hopefully comprehensive Introduction (Building Information Management)
Egbert Dittrich, EGNATON e.V.	EGNATON CERT Report

EGNATON

European Association for Sustainable Laboratories

Europäische Gesellschaft für Nachhaltige Labortechnologien e.V.

Certification of Sustainability

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EGNATON CERT, a new certification system for sustainable laboratory plug-in-units, apparatus and equipment is presented. The article explains the background and the method and especially the incitement for certification of sustainability.

General

In the more professional, especially less emotional business to business environment, advertised claims that available products are sustainable or otherwise meet environmental popular demands are taken up with skepticism. Sustainability is more or less desirable but also noticed as little differentiated and poorly quantified. Nevertheless, tendering bodies at national and European levels are asked to specify sustainable characteristics of the products. In Germany it has been clearly stated that the public sector in all areas of sustainability calls for the construction and procurement with the BNB System[1]. For large areas of the construction industry, including research buildings, rating systems are available (DGNB German Sustainable Building Council, LEED (USA), BREAM (UK), etc.).

Assuming that these systems not only represent business ideas, but also correspond to real social concerns, the existing methodology that does not take into account the processes inside the buildings must be seen as questionable. The impact of equipment and process technology-related research in research buildings exceeds, as a rule, the sustainability of the building considerably, in most cases by 10 orders of magnitude. If one wants to make the whole socio-technical system laboratory more sustainable, equipment, furnishings and plug-in-units must be considered in the overall balance.

The focus on water consumption in social spaces, heating and even facades is of secondary importance and does not take into consideration consumption and especially the production of energy in the laboratory process, but has a populist effect. Of course, the building needs to be designed to be sustainable - bearing in mind the individual circumstances - but the devices and equipment must also be sustainably planned at the same time. . Only once the entire socio-technical complex lab is sustainable itself, can it also be requested of the laboratory users to work in a more sustainable manner, which then enables the human influence factor, in addition to buildings and equipment, to contribute to its overall sustainable performance. It must be clear, that in an unsustainable and inefficient working environment, workers will also work less sustainably which will have an equally negative impact on the relevance of sustainable scientific research results. Scientific research precedes development and accompanies the product analysis and quality assurance throughout the entire life cycle. Therefore, if we want to generate sustainable inventions, researchers must also have access to sustainable working areas. This applies to all areas of laboratory science.

In this respect, there is no way around sustainability and suppliers and manufacturers are to expect that only sustainably certified products on the market will be successful in future.

Why Certification?

It is open to the tendering bodies to establish acceptance criteria under European tendering procedures, but with restrictions.

1. In practice it is not impossible to require certain qualitative characteristics of a product, if they are met by only one provider.

2. For technology such as laboratory equipment or process-related devices that are closely linked to the building or part of the technical building services, no differentiated and transparent sustainability criteria has existed until now.

3. Individual, project-specific sustainability criteria are mutually exclusive, because no comparison is possible, products are too expensive and no competition of sustainable solutions is created among producers.

Mnemonics

A. Systemic certification alone can improve sustainable quality.

B. A certification of sustainability must follow a general consensus, which is supported by all stakeholders.

The extent of complexity of sustainability, especially the balance between the pillars of sustainable, economic and environmental quality as well as socio-cultural aspects, accompanied by technical and process quality, shows, that a new concept of quality without a generally accepted system and neutral testing of this is impossible. The consideration of all categories (see Figure 1) with a dedicated assessment of characteristics is highly suitable to bring in European tendering procedures, sustainability, and to the operators, laboratory products that are guaranteed sustainable. At the same time, focus is being put not only on the value of a product solely on the purchase price, but also at the special requirements to arise during the life of the product.

What is certified?

If criteria are not determined in a transparent, quantitative method, from independent institutions, doubts regarding reliability of the claims are certain to arise. The acceptance of such a system all depends upon unassailable, consistently applied, meaningful, physical data and qualitative non-partisan feedback.

The certification ensures a level of compliance of the product with differentiating properties of sustainability while

Character	Category	Rating	Percentage of Category
1	Economic Quality	22,50%	100%
1a	LCC	16,87%	75%
1b	Availability of parts	5,63%	25%
2	Ecological Quality	22,50%	100%
2a	Energy and Services Consumption	6,75%	30%
2b	Consumables	3,38%	15%
2c	Space Demand	1,13%	5%
2d	Heat Load to Room	1,13%	5%
2e	EPDs, ecological Material	5,63%	25%
2f	Recycling and Reusage Concept	4,50%	20%
3	Human Factors	22,50%	100%
3a	Safety	6,75%	30%
3b	Security	4,50%	20%
3c	Ergonomics and Design	6,75%	30%
3d	User Guidance and Documentation	4,50%	20%
4	Technical Quality	22,50%	100%
4a	Maintenance	5,63%	25%
4b	Technical Performance – Entry Level	5,63%	25%
4c	Modularity	2,25%	10%
4d	Ability to update	3,38%	15%
4e	Diagnostics, Monitoring, Interfaces	3,38%	15%
4f	Service Infrastructure	2,25%	10%
5	Process Quality (Manufacture)	10,00%	1000%
5a	ISO 9001	1,10%	10%
5b	ISO 14001	2,75%	25%
5c	In House R&D and Product Specifications	1,65%	15%
5d	Sustainability Education	3,30%	30%
5e	Code of Conduct of Social Responsibility	2,20%	20%

Fig. 1 : EGNATON Certification Characters

maintaining a balance which must be achieved between the categories. In other words, the level of overall sustainability must equally fulfill economical, ecological and socio-cultural requirements, combined with high technical quality and reasonable process quality of the manufacturer. Each property is determined gradually and is rated with credit points, implying a total designated level. The system represents an addition to the building assessment, which provides the level of sustainability of the socio-technical system laboratory.

PCR and EPD[2]

PCR and EPD are benchmarks of considerable importance for the sustainability of a product and part of the EGNATON CERT system. They are on the way to playing a key role in European and global sustainability rules. EGNATON is working on industries PCR and EPD, which may relieve the individual (small business) supplier of the costly challenge of developing their own LCA[3]. The trial follows its own logic:

1. Definition of the product group
2. Establish a group of experts
3. Work out the LCA and the PCR according to standard instructions and under the supervision of a recognized service

Essentially, it considers the load spectrum over the entire lifetime of the product, e.g. who uses, how, how often and under which conditions the product is used until reutilization, which life cycle costs are expected within the defined load spectrum, which eco-balance figures are expected from the production, or what is happening with the product and the effects caused by its closure.

4. Determine the EPD

a. Industry - EPD

b. Manufacturer - EPD

The industry - EPD is significant and accepted when public demand and the technical average of the industry is not very different. Manufacturer - EPD based on the general consensus of PCR are determined in a second step useful when wanting to distinguish individual providers or make better.

Details: (Figure 1)
To be accepted for the certification process, applicants must meet certain preconditions. This requires a certain basic level of performance, without which no main testing can take place. This includes evidence to meet all relevant standards but also various services. For example it is required that cleaning machines deliver a 100% clean result.

At the time of printing, the system had not yet been completed. The characteristics still need to be made open to the professional community in order to give stakeholders the opportunity to present in opposition reasonable requests for changes.

Here are some details of the characteristics:

- **1a: Life cycle cost**
  In the calculation, all costs are included in all stages. The algorithm is based on a recognized calculation of the VDMA[4]. The costs generally relate to the specified load spectrum also in the context of LCA.
- **2a-f: Ecological quality**
  Profiles in this category are supplemented by EPD as it becomes available.
- **3a-d: Human factors**
  Here all the requirements of a socio-cultural nature are represented. In order to consider people in a reasonable manner the system calls this category "human factors". This is in addition to the fulfillment of safety criteria ergonomics, design and ease of use as well.
- **4a-f: technical quality**
  This category includes, among other items, the preconditions as well as the service infrastructure
- **5a-e: process quality**
  … is a manufacturing process and requires commitment to sustainability in general and social standards.

What to expect?
Based on a further strong penetration and establishment of sustainability as an intrinsic part of public expectations, sustainable products are expected to triumph. Society, on the other hand, rightfully demands that sustainability is demonstrated according to an already recognized method. Already, higher yields are obtainable for certified sustainable buildings, i.e. tenants and operators are willing to pay more for sustainable rooms - to an extent. Contractors for research buildings, starting with public users, are recognizing the benefits and changing their bidding and evaluation criteria respectively.

The investment costs as the dominant criterion will be losing their importance in favor of the LCC and other properties within the assessment.

Of most paramount importance, however, is better equipment in better buildings which quintessentially increases efficiency and competitiveness in conjunction with a responsible design of the entire social environment.

Not least, scientific research in the form of universities, research institutes and industry with millions of laboratory users in Europe must cope with public needs and bring sustainability to the point of a paradigm shift. Only by internalising this task, is the future ability of future generations assured. ■

1 BNB – Bewertungssystem nachhaltiges System des Bundes, Sustainability Assessment System for federal Buildings
2 Product Category Rules, Environment Product Declarations
3 Life Cycle Assessment
4 German Engineering Federation

Laboratories in which People can perform at their Best

The Laboratory as the Workplace of the People

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People spend a large part of their lives in their workplace. Therefore, today, great emphasis is placed upon a work environment which is safe, healthy and conducive to performance. Obviously, such an environment can be achieved in an office with less effort than in a laboratory. The laboratory is probably the most complex workplaces that exist. Under the aspect of a safe working environment here are the demands much higher.

Work in sustainable Laboratories

In the context of sustainable laboratory buildings, for a long time only a bipolar strategy was pursued by planners, with the aim of achieving a balanced ecology and economy. Today however, sustainable strategies of laboratory construction move along three coordinates that together span the economic, environmental and social dimensions of sustainability. This also defines the core concern of EGNATON.

The EGNATON-Working Group 3 "Working Conditions" (WG3) mainly deals with the social dimension of sustainability, which includes both a socio-technical as well as a socio-cultural component.

- **Socio-cultural factors** have a major effect on the condition of someone in their working environment. Unlike in their spare time, the worker does not spend their time on the job due to the deliberate selection of a particular place - thus at least they are there not voluntarily. This subtle difference makes them particularly sensitive to environmental factors socially discordant for them. Such factors may relate to external effects of their laboratory or laboratory operations or cultural irritations in the workplace. Effects of the laboratory or laboratory operations outside may be based on specific work practices or facilities. The outgoing emissions into the environment, waste heat, waste water, hazardous waste, noise or light may be relevant, particularly if an employee has the impression that the in-company mitigation efforts are woefully inadequate here. Also, the effect of laboratory buildings in the public space and the associated perceived claim is not without significance for the self-understanding and satisfaction of employees. Is the building eliciting terms like elite, power and image or rather those of responsibility, confidence and competence in sustainability? An employee prefers to work in a building that signals social responsibility and competence to cope with risk, thus making a societal contribution.

  Since socio-cultural factors of social sustainability are not further discussed in this article, we shall conclude with this: There are ultimately questions of occupational ethics that are known or become subliminally effective in this way for employees. Contrary to some statements from the boardrooms sustainability is just not an empty slogan, because many people - even many employees - have understood that without the balanced line "Economy - Ecology - Social Affairs" it cannot permanently work with the world's resources. Here, the term compliance plays a role: Is the compliance with legal frameworks really operated systematically and seriously? Or do we follow here a double standard with melodious guidelines and politically motivated commitments which exist merely on paper and will not be realized or reflected in occupational laboratory practice? Employees see this discrepancy, respond to it immediately and feel uncomfortable in their own skin.

- **The socio-technical component** covers the classic concerns of safety, such as the risk factors in the laboratory building or the safety equipment in the lab. The keywords here are: the structural and technical fire protection, the view of laboratories and laboratory building as a place of work and certain requirements for emergency prevention, such as escape and rescue routes. Of fundamental importance is also the consideration of ergonomic factors in the laboratory. Individuals require optimal performance, optimal physical environment parameters such as temperature, humidity, air movement, light or acceptable background noise. In this paper, the focus will be on the socio-technical component of social sustainability.

The Key Issue of EGNATON

EGNATON tries to bring these requirements to safety and ergonomics into line with the economic and environmental objectives of a laboratory building. Below, some examples of our previous work will illustrate what specific issues need to be resolved. It is here the special focus of the work of WG3.

Do we need such high Air Exchange Rates?

When considering the tradeoff between the three dimensions of sustainability, two dimensions are always clearly privileged, namely the economical and ecological. This is due to the rise in energy costs and the economic pressure to reduce spending. Both conditions lead to a common goal: saving energy at any price (almost).

In a laboratory building, the air exchange rate often consumes more than half of the total energy. An effective way to reduce energy costs is to reduce the energy used for air conditioning and the exchange rate of air (climatic preparation, initiation or distribution of the supply air, removal of possibly noxious air) or the night setback or closing of the fume hoods in the laboratory at night. An overall reduction of air exchange rate in the laboratory to values below $25m^3/(m^2 * h)$ would be without doubt a significant contribution to reducing energy demand and thus to reduce energy costs in the laboratory. What could be better in this situation than to take this change of air into question? Can we do without it completely or at least reduce it?

Prevention or cowardly Compromise?

Here the desired results are significant, and it requires technically profound considerations for a proper argument either way in this discussion. Measures of energy consumption reduction in the laboratory are only possible if the minimum requirements for safety in the laboratory are not affected. That means: the minimum air exchange-related safety conditions must be specified. Here especially the state of safety and occupational medical knowledge as well as the health and safety rules are used for reasoning.

Considerations of energy efficiency of laboratories often lead too quickly and conveniently to simply reducing the air exchange rate. Often, the protective aspect of the laboratory ventilation is underestimated or neglected:

- The air exchange in laboratories on the one hand protects employees against excessive inhalation exposure to hazardous substances, including carcinogenic, mutagenic and teratogenic substances.
- On the other hand, a properly designed ventilation system serves to protect against fires and explosions.

Note Situations where Air Exchange Rates cannot be reduced!

In the planning of energetically favorable, that is, lower air exchange rates in the laboratory, safety experts cannot escape the discussion with a firm and undifferentiated NO coupled to the apodictic regard to laboratory safety. They have to ask themselves under what conditions air change rates can be lowered and what residual risks are taken with it.

A reduction in air change rates below the value of $25m^3/(m^2 \cdot h)$ is not recommended in the following situations:

(1) When dealing with CMR substances in Cat. 1A and 1B substances (GHS/CLP) when inhalation exposures may occur at dangerous heights.

(2) When dealing with materials with high vapor pressure, as well as dust, and aerosols, if it can occur in dangerously high concentrations in the air.

(3) When dealing with highly volatile flammable materials and the formation of a hazardous explosive atmosphere cannot be excluded.

Working in closed equipment (e.g. in a vacuum system or in a glove box) could take place under a reduced air exchange in terms of the above scenarios (1), (2) and (3). The same applies for the correct use of functional and approved fume hoods according to EN 14175 (in particular a reduced room air change should not adversely affect the retention behavior of the trigger and outbreak).

These conditions are irrevocable and non-negotiable.

The reduction of air exchange rates to values below $25m^3/(m^2 \cdot h)$ in the laboratory naturally conflicts with the laid down state of intrinsic hazardous material protection in a laboratory. If the air exchange rate in the laboratory is to be reduced during operation, in particular, occupancy-free periods, the risks of long-term effects has to be made aware of. If the energy-saving faction of environmentalists and business economists want to agree on cost-cutting measures for laboratory buildings, taking into account the working practices and occupational health and safety in the laboratory is particularly important. Such agreements can only be called "sustainable" when they take the socio-cultural dimension of sustainability into consideration.

Night Reduction in the Laboratory

An effective way to reduce energy costs is the night reduction and night closing of the fume hoods in the laboratory. It is important to remember that the air exchange rate provides its safety performance in terms of exposure to pollutants with some time delay. A delay of adequate air exchange of up to one hour after the end of operation is therefore good practice.

What usually causes the ubiquitous pollution levels in the laboratory? It's not just the occasional spillage or the messy work of laboratory employees. Contributions are also provided by open standing or not completely tight fitting hazardous materials containers. They produce e.g. during the night, a contamination of the breathing air in the laboratory which is not discharged with the exhaust air when an overnight shutdown of the technical ventilation is active. Therefore, a temporary "advance" of the laboratory air exchange is also necessary. Also important is to make sure that the night shut off does not allow the dispersion of hazardous substances or solvents cabinets in the laboratory.

For continuous experiments that need to run overnight, special night labs are provided. There the usual exchange of air must be continuously maintained. A prerequisite for this is the possibility of a separate ventilation control for "normal" labs and night laboratories. Night laboratories can be equipped with special monitoring equipment, which report to an alarm center in the event of a fire, the formation of explosive gases or in the case that the room temperature exceeds certain limits. For the reasons presented here, in many cases, the laboratory operators make no complete night disconnection but a night setback. In the times of the night reduction the air change rate is reduced by about half in the laboratory (at full power for the ventilation for solvents cabinets). This eliminates the need for follow-up time after operation of the ventilation circuit, and also the working day lead time can be shortened considerably. The prerequisite for this is the technical possibility of controlling all of these options.

Other Motives for sufficient Air Exchange Rates

The heat loads in a laboratory arise from multiple sources. External heat sources are those loads that result from the temperature of the supply air and technical passive energy gains of the building shell, if a laboratory has its window facing outwards. Such external sources can already be avoided during the design of laboratory buildings by an appropriate building design.

More often than not, the causes and sources of internal heat loads contribute more to the problem. Exothermic reactions from experiments contribute only a negligible part of the internal production of heat. In contrast, electrical devices, apparatus and machines are being increasingly used in the laboratory. A large part of this electrical energy is converted to heat during operation. The specific heat production per square meter laboratory area has been steadily increasing for several years. Density and intensity of the heat sources in the laboratory are constantly rising. At least for the case where the heat load in a laboratory cannot be discharged through the regular air exchange, a laboratory has to be cooled. This can be expensive.

The room concept in laboratory buildings should provide a very uniform heat load distribution on the individual laboratories when it can be done through the regular air exchange without the possibility of cooling the heat load dissipation. In case this is not possible due to the high density of heat sources in certain laboratories, then the spatial concentration of such individual laboratories is recommended (horizontal or vertical). This concentration favors a central cooling system, which has energy advantages over decentralized cooling systems in buildings with displaced laboratories. When purchasing new appliances and equipment, in addition to the technical quality and economy, particular attention has to be paid to the energetic related consequences for laboratory use. The energy consumption, the amount of exhaust air, the emission of pollutants emitted and the heat load in the room should be included as decision criteria for procurement.

The lower the unremitted heat loads in the laboratory by the regular air exchange, the less energy expenditure and costs incurred for the otherwise necessary cooling process in the laboratory.

The Performance Window of the Laboratory Staff

For the energy optimization of laboratory buildings and laboratories contained therein, exist some non-energy related constraints that must be taken into account for the reduction of energy costs in any case. These mainly include three conditions:

- Healthy and accident-free working conditions in the laboratory,
- Climate compatibility of the equipment used in the laboratory as well as
- Performance enhancing environment for laboratory employees.

Amazingly, in the planning of laboratories only little relevance is given to the last of these three conditions. This ignores the fact that the human being is an important factor in the value creation process in the laboratory. This gives rise to complaints in many laboratories.

Employees complain of poor lighting, drafts, dry air, unbearable heat or too much noise. Some laboratory managers interpret this action as esoteric babble, point to the high technical standard of their labs and claim their employees are just seeking excuses for their unwillingness to work or their mistakes at work. Should the subjective perceptions be based on actual existing shortcomings, it must be expected that no employee work to their full potential at work in the laboratory under these conditions. Under such circumstances error rates are higher and the performance goes down.

The indoor Climate Dilemma

No topic seems to be discussed so controversially in the laboratory planning such as the assessment of indoor climate parameters and their adequate consideration in the laboratory. Based on many studies and experiences from laboratory reconstructions that have been designed to reach a better level of ergonomics such as we know today, however, that it is performance-enhancing, creating a physiologically favorable indoor climate and hygienic quality of indoor air in the laboratory.

Such conditions are not always easy to produce in the laboratory, because

- the room air-loads of fabrics, odors, moisture or heat must be dissipated from the laboratory and
- simultaneously, people present must be protected against the effects of health-endangering materials and influences.
- However, the assessment of the indoor climate is about much more than just the prevention of performance-inhibiting active physical influences.
- Also, the subjective perception of (thermal) comfort at work is influenced decisively by the indoor climate. All known physical factors for thermal comfort find themselves in the standards ISO 7730 and EN 15251.

Ensuring a performance-enhancing climate begins with the building design. Oversized thermal loads in the laboratory by solar "gains" can be avoided already by the geographic orientation of the building and the laboratory window, and the thermal design of the outer shell. By the selection of materials and equipment and a deliberate distribution and arrangement of sources of pollutants in the building also planning related material loads can be minimized in the laboratory. The supply air quality has a direct impact on the indoor air quality in the laboratory; operation with secondary air would be as well considered. In most laboratories, however, an operation is not permitted with circulating air.

Already in the building and laboratory planning phase, the intended target intervals for air temperature and humidity should be determined for the laboratories. The type of heating or cooling in the laboratory plays an important role for the later temperature of the floor, walls and ceiling. At high air exchange rates in laboratory, air movement is basically unavoidable. The only question is whether certain flow rates of the air are still beneficial to the performance of the employees. In this case room geometry, furnishings and condition of the air diffusers play a major role.

What Planners need to know about comfort Conditions?

Workers reach their optimum performance only at ambient temperatures between 20 and 23°C. The performance of people decreases above 26 degrees Celsius significantly. Depending on the physical condition, the power reduction is three to twelve percent per degree Celsius above the temperature of 26°C. An asymmetric radiation temperature in the laboratory can lead to embarrassment. Especially asymmetric radiation caused by warm blankets or cold walls (windows) is perceived as unpleasant. It becomes critical, for example, starting 11°C differences between the floor and ceiling. Even with a too warm or too cold floor people may feel uncomfortable due to the heat sensation on their feet. Acceptable is a temperature margin of 10°C. Temperature cycles can occur due to the temperature control in the laboratory. If the peak-to-peak jitter is less than 1 K, the comfort is usually not compromised. Higher peak fluctuations may reduce the comfort.

The air velocity in the laboratory affects the convective heat exchange between a person and the environment. Because of the associated heat loss the general physical thermal comfort is also affected. Usually, air velocities from 0.1 to 0.15m/s are still perceived as pleasant (at conventional temperatures and turbulence levels of indoor air). Increased air velocity, however, can be used to equalize the thermal sensation by an elevated temperature. Whether actual advantages are achieved by increasing the air velocity depends on clothing, physical activity, and the difference between the surface temperature of the clothing / skin, and the air temperature. Therefore, the increase in air velocity for cooling purposes should always be decided on the specific case.

The parameters room air temperature and relative humidity are not physically independent. Typically, a 10% increase in relative humidity is perceived to be as warm as a higher by 0.3°C operating temperature. At higher temperatures or higher levels of physical activity, this influence is much greater. If we put up a coordinate system from room temperature and relative humidity, the optimum performance interval can be represented on each axis. This results in a core box which is referred to as comfort window. It is delimited by the following temperature-humidity couples: (17°C, 72%), (23°C, 63%), (25°C, 35%) and (18°C, 38%). Each point in this window corresponds to a comfort level with affiliated pair of two values (relative humidity, room temperature). As soon as we exit this window, we also leave the state of thermal comfort. Then laboratory staff cannot provide their full performance in the long run.

The comfort window also has a second aspect, for the health of laboratory staff is the air pollution control function. If we consider typically pathogenic or harmful, air hygiene factors, then one finds:

- Bacteria, viruses, fungi and mites show their least effectiveness in the interval of the relative humidity of 40 to 60%, which corresponds exactly to the humidity interval of comfort window.
- The likelihood of developing an infection of the respiratory organs, or from allergies or asthma, is in the interval of the relative humidity of 40 to 60% at its lowest.
- Especially in the laboratory, the not unlikely chemical interactions between harmful substances and room air are still very low in the interval of the relative humidity of 40 to 60%.
- And finally comes the ozone production in the interval of the relative humidity of 40 to 60% rapidly to zero.

In short: In the comfort window air hygienic parameters have a relatively harmless potential, and we can control this parameter best.

Conclusions for planning Perspective

Saving energy in the laboratory is desirable and important. Nevertheless, we should respect the principles of sustainability to the desired result of such measures. Therefore, efforts should be made for planning a balance between economic, ecological and socio-cultural factors.

It should be recalled that the energy consumption in a laboratory depends on several factors, for example,

- Type of the laboratory (chemical, physical, biological, genetically ....)
- Usage patterns of the laboratory,
- Electricity consumption and heat sources in the laboratory,
- Energy efficiency of the laboratory building and
- Location of the laboratory.
- So what we strive for, when we speak of a sustainable laboratory, can be summarized as follows:
- The laboratory is a socio-technical system in which people interact continuously with equipment, machinery, hazardous materials and safety equipment.
- Such a system must be designed first and foremost so that the people working there are not exposed to harmful stresses and health hazards.
- In addition, people can only reach their best performance in the laboratory for a long duration when the environmental conditions are optimal for them.

Without a holistic consideration of all three dimensions of sustainability in the construction and equipment of laboratories, there is the risk of misallocation of investment funds. Worse, subsequent necessary corrections cost many times the investment initially saved. That should be an argument for unilaterally economically oriented builders and operators that is not completely foreign to them, because that meets their interests. Whoever is involved as an investor for a new laboratory building, therefore, is a naturally of sustainable laboratories.

Conclusion for the planning Process

In general, the demand for sustainability does not simplify the communication conditions in construction meetings. Quite the contrary! Here the obstacles to communication resulting from the different professional cultures are even intensified. In this case the contributions of architects, engineers, users, scientists and safety experts are strongly influenced through their own world views and value systems. This frequently results in surprising new interests. At this level, different interests are to merge in practice only with a certain amount of preparation for such meetings.

For the discourse on sustainable laboratories, the three-pillar model has been styled as much as is required for the mutual acceptance of the respective interests of the environmental, economic and social agents. In particular, we associate with it the expectation that the parties put the common focus on the equal consideration of all three dimensions of sustainability, despite the role the diversion of their interests play in further planning. Result: the focus of the sustainability discourse is directed to the associated institutional innovations with the sustainability debate, the importance of consensus-oriented, dialogue-participatory procedures for defining and implementing the sustainable development principle.

This must also be reflected in the practical processes of planning a laboratory or a laboratory building. It must be ensured, that upon deciding for or against the discussed plan variants, substantial reasoning is given which corresponds to the commonly arranged sustainability goals. ■

Sustainable Instruction in Occupational Safety

Optimizing Occupational Safety with Blended Learning

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www.zeus-portal.de

The industrial park operator Infraserv Hoechst initially developed an innovative training concept (ZEUS = future of efficient instruction and training) for themselves; ZEUS is now also in use by many customers.

Blended learning combines the advantages of computer-based as well as interactive game-based learning with classroom training.

The sustainable anchoring of the learning ultimately leads to more legal compliance and optimizes occupational safety in enterprises.

Challenges

As in many other companies, the employees of Infraserv Höchst must complete numerous annual instructional modules: from training on general safety and health issues on emergency procedures, handling hazardous materials, personal protective equipment to concrete operating instructions.

For those responsible for in-company training it is very difficult and time-consuming especially around shifts or when workers are field-based to plan classroom trainings and ensure that

- All staff is trained
- The content is understood and
- The instructions are documented legally compliant.

Blended Learning - the Optimal Mix

To optimize training, Infraserv Höchst has developed the innovative blended learning concept ZEUS, which consists of a combination of e-learning, interactive game-based learning and classroom training.

Sustainable Learning with Entertainment Value

With 100 e-learnings (figure 1) developed internally by Infraserv, instructions can be carried out more flexibly.

Depending on previous knowledge and experience, each employee can learn in their own individual pace. At the same time all employees achieve a common level of knowledge.

Due to the comprehension test (figure 2), not only the willingness and motivation to learn is increased, but also the success of the training can be checked and legally documented. An automatic reminder ensures full participation of all employees.

Fig. 1: Each learning module requires a processing time of 15 to 20 min. - A period of time in which employees can concentrate easily on the content.

Fig. 2: The comprehension exam at the end of a learning module is an integral part of the instruction.

Game-based learning (figure 3) motivates employees to deal with a tedious subject such as occupational safety as well.

Nevertheless, classroom training remains an essential part of instruction when

- processes in practice (e.g. handling hazardous materials) or
- coordination skills (e.g. handling of forklift, crane)

are conveyed or the main focus is on collective learning in a team.

Here too, game-based learning methods (using voting devices) can be used with which the employee actively participate in the training.

Evaluation and Documentation

In ZEUS, it is possible to plan, manage and document legally in one system both the electronic training as well as classroom training.

By documenting the completed training modules in this system, learning content relating to each employee can be checked for previous years at the push of a button (figure 4).

Through detailed analysis of all questions, gaps in knowledge and understanding, problems can be identified and corrected - an important contribution to accident prevention.

Practical Tips

In order to successfully introduce blended learning, the following points should be considered:

- Early integration of all stakeholders (work council, IT, human resources, employees, decider etc.)
- Top priority given to e-learning
- Adequate information and communication
- Creation of an integrated training schedule (blended learning)
- Equipment training for the target group
- Motivate employees
- Creation of an appropriate learning environment

Instruct Sustainably with Blended Learning

To instruct sustainably, it is important to use different methods and media (forms of learning and sense) and to actively involve employees.

The probability of retaining the content learned increases significantly. ZEUS has contributed to make the instruction at Infraserv Höchst more effective and sustainable. ■

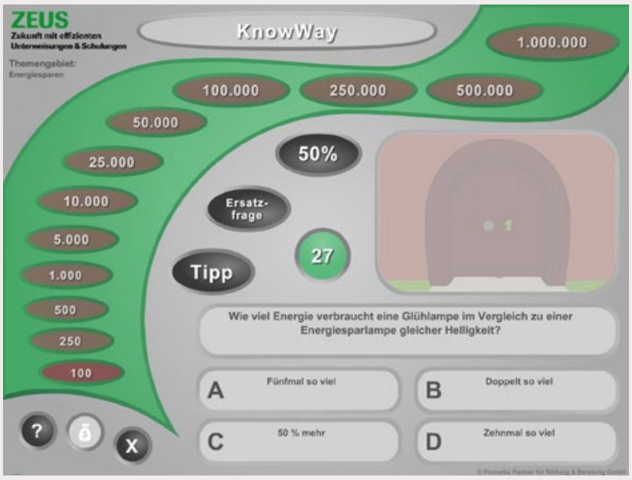

Fig. 3: Employees become motivated by game-based learning

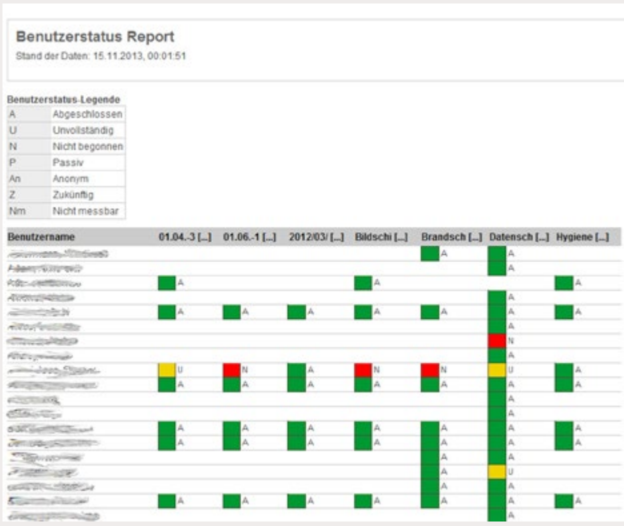

Fig. 4: Through various evaluation options instructions can be checked

Good Ventilation Practice in Laboratories

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The key issue to achieve sustainable laboratories for sure is the ventilation. It requires a structured procedure.

Air distribution in laboratories is affected by a variety of parameters. It is therefore very difficult to make general recommendations for designers and operators. Nevertheless an attempt is made here to address several general approaches for practical application with regard to establishing a ventilation concept in consideration of all safety-relevant regulations. Reference is also made to the 1996 RELAB[1] study, which has not lost anything in terms of relevance yet.

Influencing Variables

Primary

- Air volume based on
  - Utilization (type of lab)
  - Statutory minimum requirements
- Substance concentrations
- Thermal loads
  - Equipment
  - People
  - Lighting
  - Façade
- Humidity

Secondary

- Operational change in
  - Inlet air temperature
  - Air volume (load adaptation)
  - Occupation
- External influence
  - Outside temperature
  - Sun exposure

Objectives

The purpose of design must be to minimize the effects of influencing variables and identify a system of maintaining a high level of air flow stability given the token interactions.

Possibilities of reducing influencing Variables

A first step in design is to analyse the options of designers and operators with regard to reducing the influencing variables within the framework of specified requirements which are listed above.

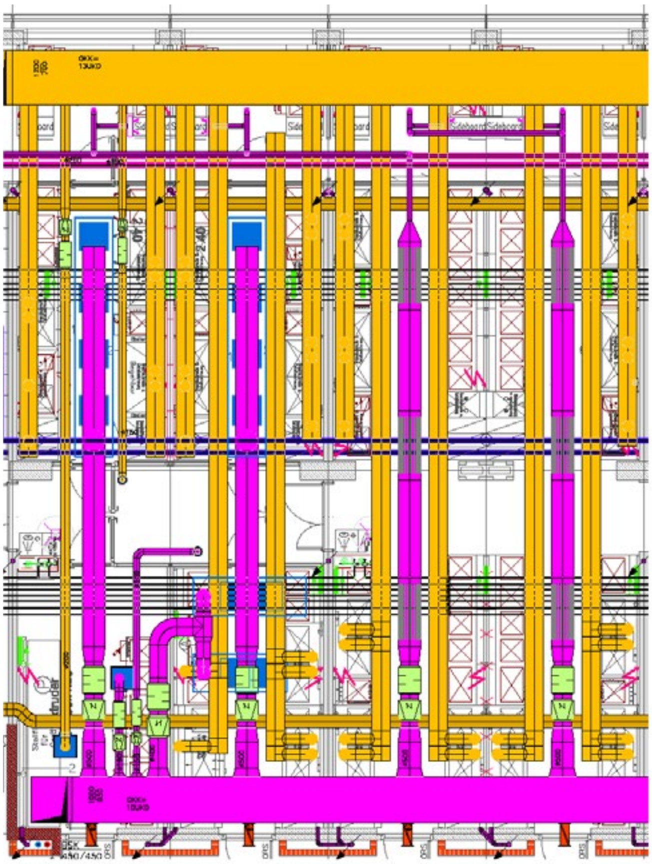

Fig. 1: Laboratory with high Occupation

These are primarily:

- Substance concentrations limited by controlled working in fume cupboards or using extraction at the source.
- Thermal loads by
  - Effective sun protection
  - Façade design
  - Direct water cooling of equipment (instead of heat dissipation in the room air)
  - Encasing of equipment with direct inlet and outlet air connections
- Reduction of air volumes
  - Load-adjusted operation with intelligent control
  - Specially designed extraction systems as required

Safety aspects have to be considered adequately in any case.

Steady Air Flow in Rooms

As demonstrated by the RELAB study, stratification flow with load-adjusted air volume is not suitable for establishing a clean air layer up to the breathing zone in laboratories due to the significant thermal impact by people and equipment.

This is only achievable by providing a mixed airflow from the ceiling using air outlets ensuring an equally distributed low substance concentration level and rapid nullification of the temperature difference between inlet and room air by room air induction.

Suitable solutions are swirl and slot diffusers alike, since they allow for maintaining a comparatively steady flow pattern even under changing conditions - as they generally occur in operation - with regard to inlet air temperature and air volume. A prerequisite for this, however, is that appropriate outlet settings and even deactivation of individual outlet elements for load-adjusted control is taken account of and implemented.

If fume cupboards are located at very short distances to each other (cf. figure 1) and with air change rates of > 18h-1, increased draft perception in the room is to be expected. In this case, special solutions are to be identified in order to reach a compromise between process-related high air exchange and air speed in the occupied area.

One potential solution for work environments with low temperature differences between inlet and room air is the use of low-turbulence outlets (e.g. fabric outlets). If these are supplemented by support jet, the resulting flow pattern is comparatively steady.

Low-turbulence outlets, however, are actually not very suitable for use in environments with high temperature differences (> approx. 3K): due to its higher density, cold air will drop down and lead to undesirable flow conditions by displacement in combination with confined room geometry.

The same applies to low-turbulence flow if thermal lift over the equipment leads to completely uncontrollable flow conditions. Low-turbulence outlets are also difficult in high temperature operating conditions, since due to its low density, hot air will not penetrate the room, but form a hot air layer beneath the ceiling and be directly discharged as such. Individual analysis regarding the type of outlets and a reasonable combination of outlet types as necessary is therefore indispensable.

The provision of localised recirculation coolers, naturally, must also be focussed upon. Especially tangential air outlets in combination with room air flow patterns may result in not only unpleasant draft perception, but also have a negative effect on the retention capacity of fume cupboards and the discharge of hazardous substances from the occupied area. This criterion must also be observed for the arrangement of biological safety cabinets, which may also cause room air flow disturbance and imply the risk of aerosol emissions.

Procedure for Design and Implementation

The previously-described catalogue of activities should be integrated in design by close coordination among technical and lab designers, users and architects, with a special focus on the reduction of influencing variables - not least due to their energy and cost-saving effect.

In general it is reasonable to consult manufacturers regarding their concepts when appropriate air outlets are selected, so that their special experience may benefit the project. In cases with particular requirements, flow modelling (e.g. CFD) will also be useful, because both various outlet and load configurations may be investigated. If a building with a large number of standard laboratories is planned, where especially high loads or air volumes occur due to their use, a 1:1 test in a model lab is also recommended. This allows for determining the optimum result by comparing the behaviour of various air distribution variants with changing influencing variables under reproducible conditions. Another benefit of a model lab is that not only construction and installation work may be optimised on 1:1 model, but also future operating procedures may be improved.

Functional Check

In any case, commissioning should be followed by a functional check under real operating conditions, where not only air volumes and the function of control devices are tested and documented, but also where air distribution is checked for compliance with design requirements (i.e. the adjustment of outlets, the inlet air temperature, the flow pattern and the retention capacity - DIN EN 14175 Part 4 „On-Site Tests" - at the least favourable measuring point).

This test indeed only allows for a snapshot - for the processes in a laboratory during operation are too diverse - but the general mode of action may be verified at reasonable expense.

Summary

Due to the significant number of effective influencing variables in laboratories, a general rule for good ventilation practice in laboratories may only be defined with restrictions.

In order to ensure steady room air conditions, the 1st step recommended is to minimize disturbing influences and then develop an air distribution system to ensure the discharge of substance concentrations and thermal loads in compliance with statutory requirements.

In general inductive outlets are more suitable than low-turbulence systems.

With regard to the high complexity of use requirements another recommendation is to verify design considerations by computer-based room flow simulation or - even better - by a 1:1 model.

A functional check including measurement and documentation of major design parameters is urgently recommended. ■

1 RELAB – Nutzungsgerechter Betrieb Raumlufttechnischer Anlagen für Laboratorien [Appropriate operation of air-conditioning systems for laboratories]

Extract Air of what Kind in Laboratories?

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The needs for laboratory extract air in the laboratory are resulting from the extract equipment of laboratories and the room extract. Extract air equipment are laboratory facilities, which require fixed extract air flows for their function and have an air outlet. Extract air equipment operate temporarily or continuously with constant or variable air volume (VAV).

The main extract equipment in the laboratory is:

- Fume cupboard extraction
- Extracted work stations
- Ventilated incubators
- Weighing work places
- Bench top extraction
- Spot extraction
- Sniff extraction systems
- Vacuum pump exhaust
- Safety cabinets
- Under bench extraction
- Base extraction
- Floor extraction

Extract air system requirements are very different for the exhaust air equipment particularly. Facilities need a defined volume flow and other systems perform a vacuum system. Air flow, pressure drops, temporal availability and the contamination of extract air are additional parameters for the extract air equipment. Laboratory fume cupboards can be equipped with filters or extract air scrubbers and these fixtures have significant pressure loss. Point extraction systems need a constant vacuum at the connection point with a manual valve for the air volume control. The extraction of the sniffer is a vacuum system also. The vacuum pump extract air for rotary vane oil pump is loaded with oil mist. Work station units or in part, fume hoods are turned on and off, whereas safety cabinets require a 24-hour air flow available. It is first obvious to operate for the various extract air technical units with their own extract systems that are specifically adapted to the requirements. A separate extract fan installed on the roof for each single cupboard hood in some European countries is still common. This installation grew out of the fear that in the extract duct the air could react with each other from different laboratory fume cupboards.

Hazardous Materials

The most important workplace for the handling of hazardous materials is the fume cupboard, realizing that in the laboratory a variety of hazardous substances in conventional laboratory quantities is handled. These substances can roughly be divided into three groups:

- Corrosive substances (acid, lye)
- Volatile organic compounds (solvents)
- Dusts

Fume Cupboard

The fume cupboard must insure protection objectives, which are the retention of volatile hazardous substances, spray and splinter protection and dilution of contaminants and the dilution of explosive mixtures. Air change rates per hour achieved in the fume cupboards is at 400. For detailed explosion protection considerations, we know that an evaporation of 200ml of ether in a 1.2m wide fume hood creates a concentration of 1.3vol% after 10sec at the connection nozzle, which decreases rapidly.

This theoretical assumption - even with the highly volatile ether a spontaneous evaporation is not possible - would have to take place simultaneously in two adjacent laboratory fume cupboards, which is very unlikely. Moreover, there are very few substances which react together spontaneously without activation energy. Highly reactive substances usually burn spontaneously already in the fume hood in contact with atmospheric oxygen. Ammonia and hydrogen chloride react spontaneously to ammonium chloride, which precipitates as a white powder. If it were possible to bring together two substances which react explosively with each other spontaneously, then this also results in no risk, since the low concentration can only lead to a deflagration. Enrichment also by condensation in the extract duct system shall be excluded in a continuous extraction mode, since the substances are continuously carried out. In a turn-off fume cupboard with single fan, the risk is much higher, since it may lead to condensation at too early shutdown and re- release for the enrichment of substances may occur in the condensate.

Safety Equipment Modules

The laboratory is no production with recurring tasks. The laboratory is subject to constant change. The number of safety equipment modules such as fumes cupboards, is dependent on the activity and furthermore also changes with the work. Retrofitting a fume cupboard with an extract air duct on the roof is very expensive and often impossible for lack of space. In old laboratory buildings with individual fans for laboratory fumes therefore the necessary retrofitting of fume cupboards is not done, resulting in unacceptable risks to employees. In addition to the lack of flexibility separate individual systems cause considerable investment costs and the installation of an effective heat recovery is not possible. The installation of a common ventilation system extract air for all technical equipment is also not sustainable because the connection of devices with different pressure losses leads to significant operating costs. The central extract device must generate the pressure for the device with the highest pressure loss. Increasing the pressure to 100Pa channel pressure increases the power consumption by 10%. The connection of a fume cupboard with extract scrubbers without a separate booster consumes more energy than a highly efficient heat recovery saves. The connection of the safety cabinets for solvents, gas bottles and leaches and acids to a central extract air unit with space and fume cupboard extract air, requires a lot of small air flow controllers and an increased duct pressure, because safety cabinets have opposite fume hoods an increased pressure loss. Whereas the extractions spot arms - even if the manufacturer often incorrectly specifies increased pressure losses - can be connected to a common exhaust system. A manual adjustment of the source extraction is not possible then unless for each source extraction pressure regulators will be installed. Manual adjustment of source extraction causes no possible integration into the room balancing. If the installation of flow measuring devices shall not be realized by integration into the room control, the extraction arms should be connected to a constant air volume flow controller.

Sustainable Design

A sustainable designed air handling unit for a laboratory building is appropriately designed. The combination of large quantities of air – room, fume cupboards and point extraction – in a central extract system with heat recovery and the installation of a separate redundant powered extract system for safety cabinets have proven for many laboratory buildings. Separate extract systems are installed for isotope areas prescribed in Germany starting at safety level 2, and fume scrubbers and filters. Space for retrofitting of extract air ducts of special work places is indispensable especially for research laboratory buildings. ■

Sustainable Air Ventilation using an Example of one of the most contemporary Ventilation and Service Systems for large Lab Areas

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How Things are now

The only unknown is what the future holds laboratories. This also applies for the design of research buildings as well. The change of basic parameters surely is developing quickly and requires a fundamental change of processes and course of action.

Due to recommendations, regulations and laws in terms of the lab planning processes, no change is to be expected.

The most important driving forces for lab planning are: **Flexibility, Safety, Comfort and Sustainability.**

Large lab areas very closely accommodate the present needs of occupants and users. The complex design of even single laboratories cannot be accomplished by usual 2D processes let alone the design of large lab areas. 2D based planning together with coordination of the single trades can only lead to suboptimal results. Besides this, the planning is expensive and requires a lot of time.

Once the knowledge of user independent design of large areas research laboratories is obtained, the design of the complex lab building is possible within six months. Data of all trades are merged in the planning process and can be jointly examined.

Universities and industry have come to the recent conclusion that major problems today demonstrate an insufficient flexibility and more or less improper ventilation. Use of standard ventilation components for laboratories appears unsuitable. As a result, the large number of fume cupboards with malfunctions currently in use does not provide for a safe working environment due to the counterproductive design of ventilation components.

Further focus must be placed on the design of the fume cupboard and room extract. Due to numerous fittings under the ceiling, conventional extract systems don´t allow flexible extraction units and therefore flexible lab layouts.

Fig. 1: Research Centre Nestle

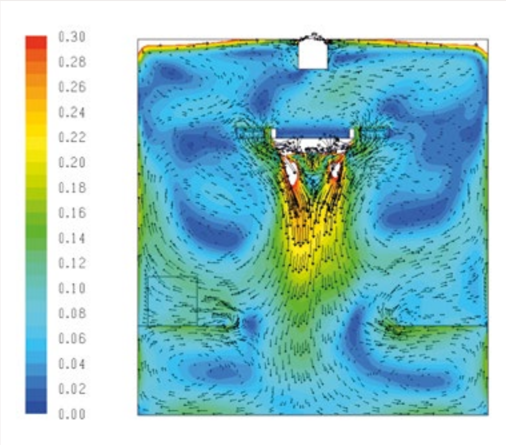

Fig. 2: Supply air pattern

Fig. 3: Thermodynamics of supply air

The question is what if a system covers both problems – insufficient air ventilation and flexible room layouts?

Future

For some reason it appears to be clear that the key issues insufficient air ventilation and flexible room layouts are the two sides of a coin, in other words both problems have the same solution. A most contemporary lab ventilation system[1] allows providing occupants with comfort and safety and anticipates future needs in other room concepts. The source is a user development of the ETH Zurich[2] and its improvement in the last 13 years. The ceiling based construction follows mechanical engineering principles and provides highly ergonomic work stations. For the time being more than 200.000 m² large lab areas are being examined to certain whether their lay outs can be modified accordingly.

Laboratory Ventilation[3]

The most spectacular element in the service ceiling systems is the air outlet. The supply air outlet is made of a translucent membrane complete with integrated lighting. The membrane forms a perforated duct, designed with CFD soft ware[4].The most desirable outcome is a turbulent free, very comfortable high efficient supply air pattern with very low flow velocities <0.2 m/sec.

The duct is located above the aisle between the benches in approx. 2.8m along the entire depth of the lab.

Supply Air Outlet

Regardless of how outlets such as standard-, textile-, displacement- or laminar flow ventilation are formed, below the outlet a head up drop of air is formed. The fresh air accelerates within a small section in a downward movement and depending on the required air rates, and temperatures, at velocities much less than the draft noticed by the occupants.

The membrane air outlet with its micro perforation in stripes on the sides generates an impulse allowing a micro induction. The micro induction allows mixing the fresh air nearby the outlet with the warm room air to a certain extent. This effect reduces the downwash. The sideways escaping supply air conglomerates directly underneath the membrane and forms a single wide pattern, flowing down slowly by effect of the induced warm room air. The downwash velocity limit at is about 0.20-0.25m/sec, depending on air exchange rates (12+) and supply air temperature (15°C).

Supply Air Pattern

Supply air drops like mist towards the floor above the aisle. Depending on the air rate, parts of the supply air are diverted at the bench edges heading across the bench tops. Most of the supply air, however, flows to the floor and dissipates to the sides.

The surface of the membrane is cooled by the supply air and works like a cooling sail by absorbing the room heat by heat radiation and free convection. This contributes to facilitate the heat release with less risk of draft than usual systems. Particularly, the subjectively felt temperature (average of air - and convection temperature) in the occupied zone is more comfortable. In this case air temperature may be somewhat higher (approx. 1-2°C). This will reduce the air volume and finally the energy consumption.

Thermodynamics of Supply Air

Plug–in-units in laboratories are usually located on or underneath the benches on both sides. The resulting heat load generates a strong thermal source above the benches, absorbing air from the surroundings. Reaching up to the ceiling, the strong upward flow is redirected to the middle of the room.

Two counter rotating air rolls are produced. The extract air duct is installed at the point where the air rolls are at their closest.

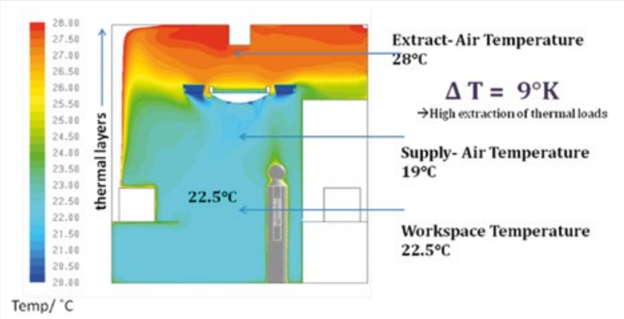

Fig. 4: Thermal efficiency

Fig. 5: Ventilation design of a lab

Extract Air

Locating the extract air duct[5] under the room ceiling in the highest position allows extraction of the warmest and the most contaminated air. The system is designed to add the extract of fume cupboards, spots, housings or small cubicals.

Thermal Layers

Compared with standard mixing ventilation and their resulting relatively constant temperature in the entire lab, the new system works with thermal layers. If the temperature in the occupied zones is held at a constant 23°C due to the thermal layers, the temperature directly underneath the ceiling is reaching 30°C. This would be exactly where the extract device is installed.

Thermal Efficiency and Sustainability

Due to the thermal layering the system moderates the temperature not for the entire room but the occupied area only, i.e. the zone between ceiling grid and ceiling is less interesting in terms of the thermal design. Usually the extract temperature with a standard design comes with 23°C. The new system works with 30°C. By means of balancing ΔT between supply and extract air, a conventional systems needs to be operated with a much lower supply air temperature. The increase of efficiency comes close to 30% in particular cases.

Work Safety with Respect to Emissions

By means of CFD-software an SF6 emission was simulated. The maximized mixing ventilation shows a concentration of 3.54ppm in the room versus 2.77ppm of the new ventilation system.

Due to the counter rotating air rolls, the room is split longitudinally and the contaminant loads are 30% less than the standard ventilation. The result of the simulation is very much like the measured recovery time.

In other words, the safety of a ventilation system is not only determined by the air exchange rates, but much more by the efficiency of the ventilation system overall.

Flexibility and Thermal Loads

Typically the ventilation and cooling performance of a lab building is designed according the needs of the users. In the case where users are unknown, the design is clearly limited. Fan coil units are for the time being the only solutions available in order to decrease temperature. These devices are expensive, generate high LCC and provide massive draft.

Cooling retrofittable

The new ceiling installed system can be retrofitted with heat exchangers or cooling baffles and can recuperate up to 350W/m². ■

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Energy-efficient and flexible Laboratory Building with native BACnet/IP

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The main energy costs of laboratories are caused by fume hoods with a very high air consumption of conditioned air (temperature/humidity) to avoid toxic emissions effectively. A standard fume hood (width: 1.2m) needs approx. 4,380,000m³ air during constant continuous operation. This causes operating costs of approx. 8,760.00€/year (assumed costs of 2.00€/1,000m³ according to benchmarking of Bauakademie for the IFMA-working group).

By using a fume hood controller with "low flow night operation" and an automatic sash controller SC700 the yearly costs can be reduced to 2,532.00€ which means a saving of 71% or 6,228.00€/year.

A further reduction of the operating costs can be realized by a consequent use of a multivendor capable and open network. Therefore proprietary bus systems are ruled out and the most advisable as well as the most flexible system is the world standard BACnet/IP.

What does native BACnet/IP mean?

Native means that e.g. fume hood controllers with the communication protocol native BACnet/IP "speak" directly with the connected building management system without any gateways. **B**uilding **A**utomation and **C**ontrol **Net**works is a royalty-free and multivendor capable communication protocol for the building automation and is equally appropriate for management, automation and field level, especially for HVAC, light control, safety, access control and fire detection technology. Due to interoperability the operating of systems from different manufacturers is guaranteed. BACnet provides a trade-spanning and consistent communication from the building management system, the digital control systems to the sensors and actuators. That implicates important economical advantages, e. g. investment security, simple installation, commissioning and system extension as well as a flexible change of use, optimized operation and a transparent cost structure.

BACnet is standardized according to DIN EN ISO 16484-5 since 2003 and the only worldwide accepted communication standard for products and systems of the building automation. The communication occurs particularly consistent up to the field level via Ethernet and is therefore fast enough to perform complex control algorithms and room balances as well. By cabling with patch cables (plug and play) the wiring, installation and commissioning costs can be reduced additionally.

Wiring mistakes are completely unknown due to the pre-assembled cables. BACnet simplifies the planning and bidding procedure of different trades by using only one standardized and multivendor capable communication protocol. Other protocols such as LON and EIB/KNX can be connected smoothly.

Annual total operating cost in EURO (€)
Given: 1,000 m³ = 2.00 €, 1 fume hood with 500 m³/h
Day operation = 2,600 h/year
Night operation = 6,160 h/year
DF = diversity factor

Air consumption m³/year	CAV	Day/night operation	FC700 DF=70%	FC700 with low night flow+ SC700 DF=50%
Day m³/year	1,300,000	1,300,000	910,000	650,000
Night m³/year	3,080,000	1,540,000	1,000,000	616,000
Total m³/year	4,380,000	2,840,000	1,910,000	1,266,000
Annual cost €/year	8,760.00 €	5,680.00 €	3,820.00 €	2,532.00 €
Savings	0,0 %	35 %	56 %	71 %

Table 1: Annual total operating cost for one fume hood

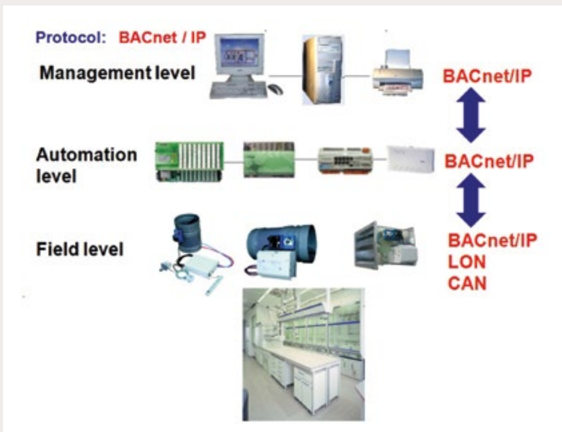

Fig. 1: Building control levels via BACnet/IP

Intelligent Room Concepts for more Safety

Apart from energy savings, the comfort of the laboratory staff is an important factor. The following criteria should be considered in planning a laboratory:

- temperature
- humidity
- pressure
- room flow behavior
- room air volume balance (for supply air and protective pressure requirement)
- room air exchange (according to national standard and application)

The freely programmable fume hood controller FC700 and the room supply air respectively room extract air VAV700 with native BACnet/IP are modular extendable and therefore fulfills room controller and DDC-functions. All required measuring values such as temperature/humidity/pressure can be connected and several independent control loops enable complex applications.

Besides the air balance and the room supply air respectively room extract air control the heating/cooling, the average determination of several temperature sensors and the humidity control is possible. At the same time the room flow behavior and the room pressure can be captured and as redundant values compared, adjusted and corrected if necessary with the calculated room balance. Trendlog, alarm/event management and scheduler are implemented as well and guarantee therefore a relief of the building management system by a decentralized outsourcing of process-controlled messages to the linked controllers in the field level.

Automation and field level melt together into an intelligent local field level and allow therefore a simple and flexible change of use.

Presence detector and touch room control panel with graphic user interface are used for an automatic or interactive log in and log out of the laboratory staff in the laboratory. Therefore the energy costs are reduced during absence via room air exchange rate, room lighting as well as heating/cooling.

Energy Saving by optimized Duct Pressure

The duct pressure optimizer DPO700-BIP is principally used in BACnet projects and adopts the optimized control of the fan-frequency converter for the total exhaust air. For this purpose the operating data (damper position and volume flow actual value) of all controllers (fume hood, room exhaust air, etc.) is sent as soon as the values are changing (change of value = COV). The frequency converter (VFC) for the exhaust air fan is adjusted downwards until the "weakest" damper stands on 80% (100% = damper fully opened, 0% = damper completely closed) and therefore is within sufficient control range.

By this measure the complete facility is optimized in such way that as little energy as possible is consumed and all controllers are still within the control range. The same approach applies also for supply air and for the activation of the supply air fan frequency converter.

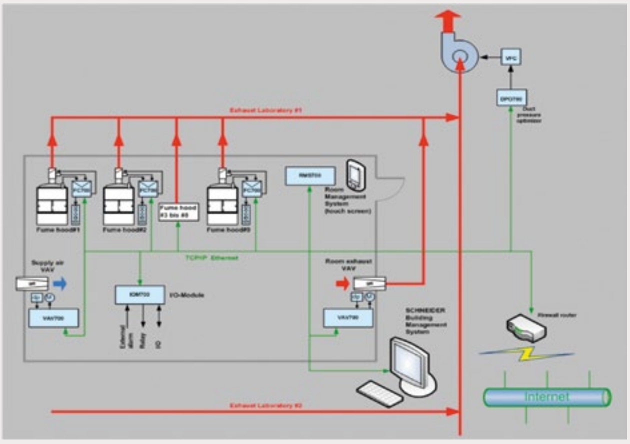

Fig. 2: Lab building in optimized energy efficient operating mode

The fans will always operate at the ideal (minimal) operating point to gain a considerable saving of electrical energy. Furthermore the sound values (flow noise and radiated noise) are significantly reduced because the dampers are always opened as wide as possible to "destroy" only less pressure. This improves the "comfort factor" considerably for the laboratory staff as well. The duct pressure is dynamically optimized to the damper positions of all relevant controllers. The automatic ventilation adjustment allows the identification of the weakest consumer or a false system configuration or installation/assembly. The complete system safety is significantly improved because of the permanent reporting captures extensions and replacements.

Visualization via integrated Web Server

All products of the 700 series (FC700, VAV700, etc.) contain an integrated web server and can be parameterized with a web browser via any customary PC, tablet or smart phone without installing special software. All device internal data and parameters are available and can be changed, password-protected via login-retrievals (read/write). A visualization of the device internal data points is already implemented in the web server and improves the clarity of the data input. Therefore remote maintenance and remote commissioning can be implemented simply and cost-efficiently. An additional visualization software module allows the simple creation of a project specific configuration of room graphics and a free adjustment of the single devices (e. g. fume hood, volume flow controller, etc.) in the room. Several linked devices can be projected and visualized to single control groups (e. g. rooms) of floors up to complete buildings. A low cost integral system solution with functions of the building management system. All necessary "bindings" can be easily established via drag & drop because the addresses of all devices within a project are known. Continuous and steadily updated documentation of the complete project is guaranteed as well.

The live status of all devices, rooms, floors respectively the complete building can be visualized with just a few clicks which simplifies significantly the maintenance and troubleshooting during operation. The remote maintenance occurs via Internet with authorized access.

Complex solutions including the visualization can be realized simply and cost-efficiently without a „classic" building management system. Alarms and operating data can be forwarded to the tablet or smart phone of the maintenance staff and a clear cost transparency with statements of air consumption per fume hood or laboratory room is guaranteed. ■

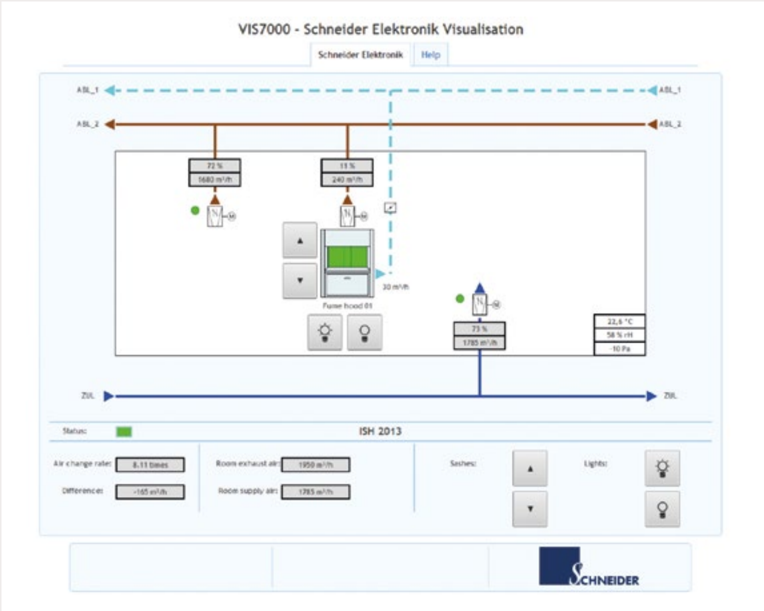

Fig. 3: Integrated web server for easy visualization

We talk native BACnet®

High-end fume hood controller - FC700 - with Internet technology (TCP/IP), native BACnet® (IP or MS/TP) and integrated web server.

- ☑ Easy visualisation
- ☑ Up to three static differential pressure transmitter
- ☑ Maintenance-free measuring system with damper and hysteresis-free high-speed servo motor
- ☑ Integrated auxilary air control
- ☑ Modular software and hardware
- ☑ Heating and cooling
- ☑ Extension board for integrated sash closer
- ☑ Energy saving due to ECO-Mode display

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Energy Consumption with Focus on Sustainability

Author: **Peter Dockx**
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The purpose of EGNATON's "Lab Energy" workgroup is to identify parameters which have an influence on the energy demand of laboratory buildings including:

- **What are the differences between separate laboratories?**
- **What are the differences for the same lab, but located in another European country?**
- **What is the impact of different types of facades?**
- **What is the impact of different energy saving techniques on the global?**
- **...?**

In order to answer these questions, the EGNATON workgroup for lab energy has setup some different tools to analyze the impact of different parameters. First it has created, in close corporation with the architectural workgroup, a "VIRTUAL" laboratory building that serves as a model for different calculations and comparisons. To be able to compare different aspects with each other, the workgroup has also developed one coefficient which encaptures the energy performance of a laboratory building, the so called E³ Value (the EGNATON Energy Efficiency Value). This single constant enables the comparison of a laboratory's efficiency based on architecture, technical aspects, location … .

Virtual Modeling

Virtual modeling is performed by specialized software. With this software tool it is possible to "build" a building on a virtual platform and test it under a variety of conditions and options to understand how it will perform before it is built. With virtual energy-analysis tools, engineers can evaluate the energy demand of a building in relation to a number of different parameters.

Fig.1: Virtual building

Definition of the Model

Our virtual building uses a simple architectural form to reduce the complexity of the simulation exercises and to isolate specific variables for the studies. From an energy modeling standpoint, the internal operations within the laboratory building are more significant than building form. Therefore, the model is not suggesting an optimal lab layout or architectural expression.

The workgroup defined the virtual building as follows:

- A 4-level building with a gross area of circa 1,400 m² for each level
- Each level has 2 labs of 415m² and 250m² of office space.
- The roof level has a technical plant area of 420m²
- The total gross/net Area is 1.42 (6150m²/4330m²)
- Inside the laboratories, the basic loads for Simulation 1 are as follows:
- Occupation Hours: 08:00-20:00
- Each lab has 40 fume hoods
- The occupied air demand = 14,000 m³/h on variable airflow and 1.500 m³/h on fixed airflow. (approximately 11.3 ACH)
- The non-occupied air demand = 4.000 m³/h and also 1.500 m³/h of fixed airflow. (approx 4 ACH)
- Internal plug load:
- Lab Occupied:55 W/m²
- Non–occ: 15 W/m²
- OfficeOccupied:15 W/m²
- Lighting Load: Lab/Off 15 W/m²
- Orientation: Labs South
- Offices North
- Building Location: Munich (Standard)

HVAC Systems – thermal Comfort

Different HVAC (heating, cooling air condition) systems within laboratory buildings have a significant effect on energy consumption and on the comfort of the occupants. EGNATON's Energy Working Group, using their 'Basic Model - a virtual laboratory building, have simulated these systems to determine the influence of a different HVAC system on energy consumption whilst maintaining thermal comfort for the occupants.

Thermal comfort is defined as obtaining a neutral value (Fanger PMV) taking into consideration temperature, humidity, clothing, etc. When these neutral conditions are exceeded, the number of hours per year are measured, so-called Weighted Temperature Exceeding hours (WTE) across the year. The definition of WTE is provided at the end of this Note.

HVAC System 1 – Basic Air System

HVAC System 1 is a simple HVAC that heats the outside air to 18°C. It uses a heat recovery system by using a twin coil system. It has no cooling provision, which means when the outside temperature is higher than 18°C, air is supplied to the labs and offices with a temperature equal to the outside temperature.

No additional heating for the labs is required; additional zone heating is provided for the offices to control the temperature to the set point of 20°C.

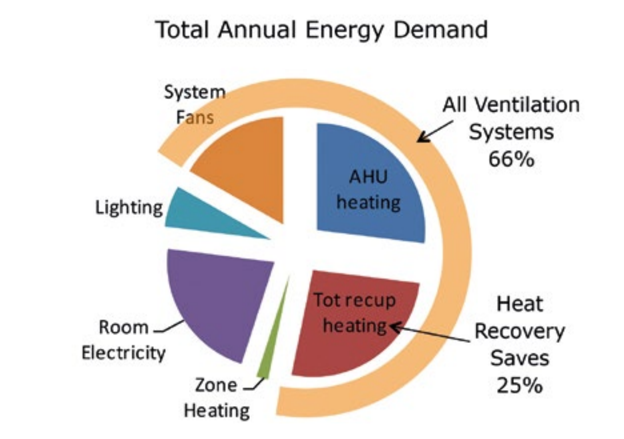


Fig. 2: Total annual energy demand

Figure 2 shows that about 2/3 of the energy demand goes to the ventilation systems, however heat recovery is able to reduce this demand by 40%; saving 25% overall. Modeling the comfort levels provided by HVAC System 1, uncomfortably high temperatures occur in the labs; especially in the summer. Modeling shows that internal temperatures can reach upwards of 35°C during periods when outdoor temperatures reach 32°C. The WTE results show that approximately 1733 hours of uncomfortable working temperature lab is reached per year.

HVAC System 2 - Cooling Coil System

HVAC System 2 is based on System 1 but with a cooling coil added within the air handling unit. This enables the supply air temperature to be controlled between 18 and 20°C. This gives a better controlled temperature for the labs. Modeling shows that internal temperatures are now under 25°C for most of the year. WTE hours are reduced to only 33 hours per year. The question is: what the influence is of this cooling energy on the total energy demand of the building? The air handler provides the energy needed for cooling down the outside air to 20°C when the outside temperature is higher. It is about 5% of the total energy demand.

Considering that this cooling energy is produced primarily by energy efficient cooling (COP=3), the energy production required for cooling reduces to 3%.

Summary

It only requires 3-5% more energy you make a much more usable environment for lab occupants.

Definitions

WTE Hours (Weighted Temperature Exceeding Hours)

WTE Hours identify the hours when internal temperatures are too high for the thermal comfort of the occupants; the higher the thermal discomfort the higher the WTE value. The WTE value is derived from the formula:

WTE = Σ 100-95*EXP(-0.03353*PMV ^4-0.2179*PMV^2)

The Fanger PMV (Predicted Mean Vote) value is important as it defines the relationship of different parameters such as temperature, humidity, clothing, draft, etc.). The Fanger PMV uses the following comfort scale:

0 neutral	
+1 slightly warm	-1 slightly cool
+2 warm	-2 cool
+3 hot	-3 cold

When the PMV value is higher than +0.5 the formula calculates the WTE Hours.

E³ Value for Lab's

It is difficult to compare different laboratory building designs and technical installations. Is one building design more efficient than the other one? Is this type of ventilation system better than the other one?

It is the purpose of EGNATON to encourage architects and engineers to design their laboratory buildings in the most sustainable way. For that purpose EGNATON has created a value, the EGNATON Energy Efficiency value (E^3 Value), to enable architects and engineers to compare buildings and system designs. The definition of the E^3 Value is simple. It is the ratio of the total energy your laboratory building needs over the energy that is really necessary for your process.

$$E^3 = \frac{\text{Total Energy Consumption}}{\text{Process Energy Consumption}}$$

Total Energy Consumption: This is the total energy that goes into the building. In our EGNATON virtual building model this is the sum of all energy that is on our pie chart. The Total Energy Consumption = SUM of the energy for AHU Heating, Zone Heating, Room Electricity, Lighting, System Fans and Cooling.

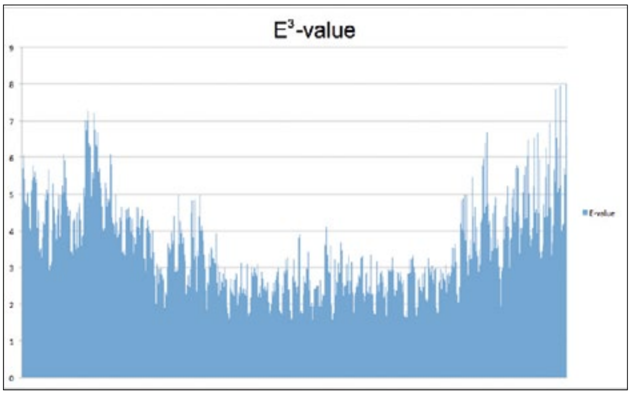
Process Energy Consumption: This is the energy essential for laboratory processes. Therefore this represents only a fraction. The Process Energy = SUM of the energy for Plug Loads and Ventilation.

We define the energy for ventilation as the product of the airflow you need for your lab with the pressure you need to achieve this flow.

$$E^3 = \frac{P_{heating}+P_{cooling}+P_{elec}+P_{light}+P_{fan}}{P_{plug\ load} + P_{ventilation}}$$

$P_{ventilation} = Q_{(m/s)}$ x Pressure $drop_{(Pa)}$
The value enables the comparison of different buildings, without penalising internal activities. The comparison can be of building design, technical installations, different locations, etc.….

Calculation of E³ Values
The E³ Value of course can be calculated not only annually, but also hourly, for example



Even with a building in operation you can monitor your E³ Value in real-time with your Building Management System in order to compare your design with the current situation.

Example 1
A sample calculation of the E³ Value was made with the EGNATON Virtual Lab Model. We made the calculations made for the same lab located in different locations in Europe.

The difference in total energy consumption resulted in the following E³ Values according to location:
Sevilla: E³ = 2,55
Stockholm: E³ = 3,38
Brussels: E³ = 2,82
Munich: E³ = 3,10

The difference in this E³ Value is a result of the difference in geographical location. The building and technical installations remain constant in the model. Since a large proportion of the energy consumption depends on outside air conditions this is also a logical explanation of the difference in E³ Value.

Example 2
We also compared a lab building the case Phase Change Materials (PCM) being introduced. The result of this exercise was that the building WITH the PCM's had an E³ Value of 4,13 compared with the same building on the same location but without the PCM had an E³ Value of 4,6.

Conclusion
The E³ Value (EGNATON Energy Efficiency Value) is a simple, relatively easy to calculate value that allows you to compare different laboratory buildings and technical installations without penalizing laboratory processes. It even enables constant monitoring of building efficiency of a Building Management System. This encourages people to constantly improve the sustainability of their laboratory. ■

Temperature of Intake Air

A brief Investigation on the Influence of the Positioning of the Air Intake

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While working in an institution with a non-cooling standard, meeting expectations of users concerning temperature and comfort issues is a challenge at the very least. In the quest for improvement, the question arises what the best configuration would be for the air intake of AHU[1]. A measuring campaign at KU Leuven during the summer of 2013 revealed some interesting results.

Background

Over the last 20 years, expectations concerning comfort have definitely increased; almost every new car has air conditioning, a lot of people have air conditioning in their private houses. Of course the same pattern can be detected for working environments and these changed expectations clearly contest a non-cooling standard. When people are working in older buildings, complaints about high temperatures are rather seldom. On the other hand, when people move to a new building, there is lot less tolerance on this aspect and they expect that summer temperatures are controlled significantly better than in the old building. To this end, a measuring campaign has been introduced in order to survey the performance of different air intakes in keeping the air temperature as low as possible. This is especially important in research buildings where ventilation is an important issue, since there is little attenuation of the temperature and temperature fluctuates together with the outside temperature. Furthermore this survey is not only relevant for buildings that are not cooled, but also for buildings with air conditioning, since it is important to minimize cooling loads; each °C less means extra savings and a more sustainable solution.

Framework of the measuring campaign

For the campaign 10 configurations of air intakes were chosen. These configurations can be divided into three families:

- Air intake with concrete plenum (code PL)
- Air intake adjacent/over a flat roof (code R)
- Air intake in the plane of the façade (code F)

Although everything has been done to ensure the results are as objective as possible, one should be aware that there are several factors influencing the results:

- Measuring errors: temperature measures with basic meters, after the campaign there was a difference of some tenth of a degree between the different meters.
- The surroundings of the different buildings: KU Leuven has three campuses; one in the historical city, one in the more typical "open" campus and one densely urbanised campus on a hill next to the city center.

In order to ensure the clarity of the result, the following decisions were made:

Fig. 1: Air intake configurations

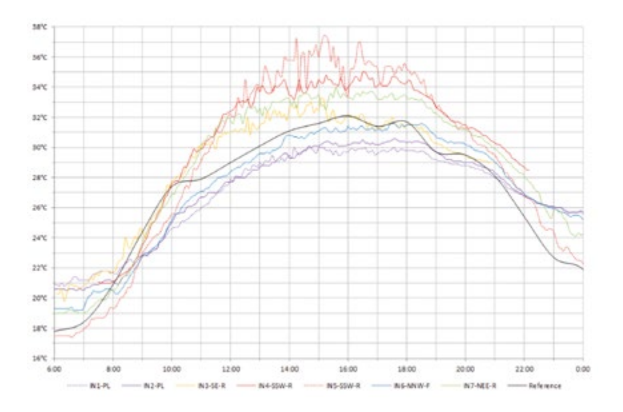

Fig. 2: Temperatures for one representative hot summer day

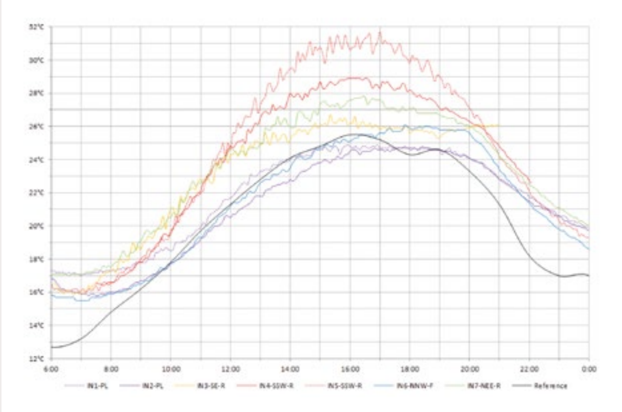

Fig. 3: Temperatures for one representative summer day

- Only the 7 most relevant results are used for this article. What is the definition of relevance in this case
- The results are compared to a reference: the official measurement of the outside temperature in the nearest weather station (in this case Zaventem, about 20km outside of Louvain).

The 7 Configurations

The results of the following configurations are analysed (see figure 1):

- IN1-PL: air intake on the inner courtyard of a bigger complex, always situated in shade. The air goes through a concrete plenum (situated in the ground) to the air handling units in the basement of the building.
- IN2-PL: air intake on the lower side of a hovering volume. The air is taken through a concrete plenum to the air handling units on the upper floor of the building
- IN3-SE-R: air intake adjacent to a white painted roof, fenced off with a wall that shades the intake around noon.
- IN4-SSW-R: air intake adjacent to a black roof
- IN5-SSW-R: air intake in a dark façade adjacent to a black roof
- IN6-NNW-F: air intake in the façade; shaded until late afternoon (5pm)
- IN7-NEE-R: air intake adjacent to a dark roof

Measurement Results

When looking at factors that result in overheating, two periods were analyzed; one where the maximum temperature on three consecutive days fluctuated around 25°C (beautiful summer day) and one where the maximum temperature on three consecutive days was above 30°C (hot summer day). For both periods, the temperatures for one representative day are shown in graphs, in particular graph 3 and 2. In two tables (Fig. 4 and 5) the results of these two periods are shown. The following figures are listed:

- Deviation from the daily average temperature during this period. Since the air handling units of IN 3 and 4 drop overnight, for these intakes this figure cannot be calculated.
- Deviation from the average temperature between 06:00h and 24:00h (highest solar load during office hours) during this period.
- Deviation from maximum temperature during this period.

period with max +/-25°C	IN1-PL	IN2-PL	IN3-SE-R	IN4-SSW-R	IN-SSW-R	IN6 NNW-F	IN7-NEE-R	REF
daily average (°C)	1,6	1,2	/	/	3,2	1,6	2,7	0
average during 12pm-6pm (°C)	-0,2	-0,7	1,5	3,7	5,6	0,5	2,2	0
maximum (°C)	-0,2	-0,1	1,3	4,1	6,8	1,8	2,5	0

Fig. 4: Measurement results on summer day

period with max > 30°C	IN1-PL	IN2-PL	IN3-SE-R	IN4-SSW-R	IN-SSW-R	IN6 NNW-F	IN7-NEE-R	REF
daily average (°C)	0,6	0,6	/	/	1,2	0,9	1,5	0
average during 12pm-6pm (°C)	-1,5	-1,3	0,6	3	3,5	-0,2	1,5	0
maximum (°C)	-2,0	-1,1	0,4	2,5	3,8	0,6	1,1	0

Fig. 5: Measurement results on hot summer day

First Analysis

Logically the measured temperatures on nice summer days (+24°C) are mainly influenced by solar loads rather than the maximum temperatures. During morning hours two groups with similar results can be distinguished; the intakes with plenums and north orientation (IN1-2-6) perform somewhat better than the others. From 12 pm on measured temperatures start to diverge.

IN1-PL and IN2-PL gain a positive effect from the concrete plenum (damping the maximum temperature). Temperatures are equal to or lower than the reference (outside) temperature. At night the reverse effect occurs, the plenum heats up the cooler outside temperature making night ventilation less effective.

IN3-SE-R reaches its maximum early during the day and is higher than the reference temperature, after this the intake is shaded and temperatures drop. On certain days temperatures even converge with the reference. A comparison with IN7-NEE-R seems to show the positive effect of the white painted roof.

IN4-SSW-F and IN5-SSW-R suffer a lot from solar loads. This effect is shown clearly on bright summer days with an air temperature around 25°C. On these days the difference to the reference rises up to 6°C.

IN6-NNW-F keeps down with the reference outside temperature, only when the intakes aren't in shade anymore during the late afternoon, temperature rises above the reference.

The IN7-NEE-R could be seen as an "average" intake. The difference when compared to the IN3-SE-R seems to indicate the influence of the black roof.

First conclusions

During the campaign large differences in temperature were measured. SSW-orientated intakes resulted in temperatures over 6°C above reference. Out of these results, conclusions can be formulated which should be confirmed in a more extensive campaign that also tries to log the other influencing factors.

The most important conclusion is that the influence of the sun should be avoided as much as possible when designing the air intake of AHU. Sun loads between 00:00h am and 18:00h have the most devastating effect on the thermal comfort in the building.

The following recommendations can be formulated:

- The intake of air should be orientated between NNW and NE, preferring N-NNE.
- Avoid the placing the intake adjacent to a flat roof. An intake in the façade is a good alternative if orientated correctly.
- When an intake adjacent to a flat roof cannot be avoided, the intake and the zone in front of the intake should be shaded as much as possible. Sun loads starting from 12:00h should be avoided in particular. A gain of 2 to 4°C can be expected.
- A reflective or white roof heats the intake air less than a black roof.
- Concrete plenums have a positive effect during the hot hours of the day (1 à 2°C compared to the reference) but at night the reversed effect occurs.

Summary

In an attempt to meet the comfort demands of users in non-cooled buildings, a measurement campaign at KU Leuven was organized to determine the effect of the configuration and orientation of the air intakes of Air Handlin Units. Although this campaign cannot be classified as "scientific", the results proved to be so divergent (up to 6°C) that on the basis of these measurements some recommendations can be made. The most important and obvious recommendation is that solar loads have to be minimized, which can result in significant gains concerning comfort issues in non-cooled buildings. In southern Europe, where the necessity of air conditioning is inevitable, these recommendations will also result in important financial gains. Finally, even though these recommendations seem very obvious, they are often not applied in new buildings. Maybe this quantification will create extra stimulus and will lead to better and more sustainable buildings. ■

1 Air Handling Units

The Quest for an appropriate Project Management Approach for sustainable Laboratory Buildings of the 21st Century

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Traditionally stakeholders have played an independent and not sufficiently connected role during the life of a laboratory building. Recent trends show new ideas are worth applying from a life cycle point of view.

There are many factors which play a role during the life of a laboratory building, and all of these may have a relevant importance at some point. If we aim to break these down into categories, we may find that there are those related to the "owning and use" of the building on one hand, the "conception and creation" of the building on the other hand and finally the "making it possible to be used".

All of these have always been part of the life cycle of the building at a certain point in time, but traditionally they have mainly worked in a line project management concept, this is to say, they have been relevant at one or another point during the building's life independent of what happened before or will happen thereafter.

Owning & use	Conception & creation	Making it possible to be used
CLIENT	DESIGNER	FACILITY MANAGER
USER	BUILDER	FACILITY SERVICE PROVIDER
TENANT	EQUIPMENT SUPPLIER	
OWNER	PROJECT MANAGER	

Fig. 1: Important relations

Nevertheless, any decision taken during the design affects the future facility management of the laboratory; certain decisions of the project manager for the main constructor during the construction stage may influence the use of the lab.

There is only one way to face this interrelation between stakeholders in order to maintain the balance of the laboratory

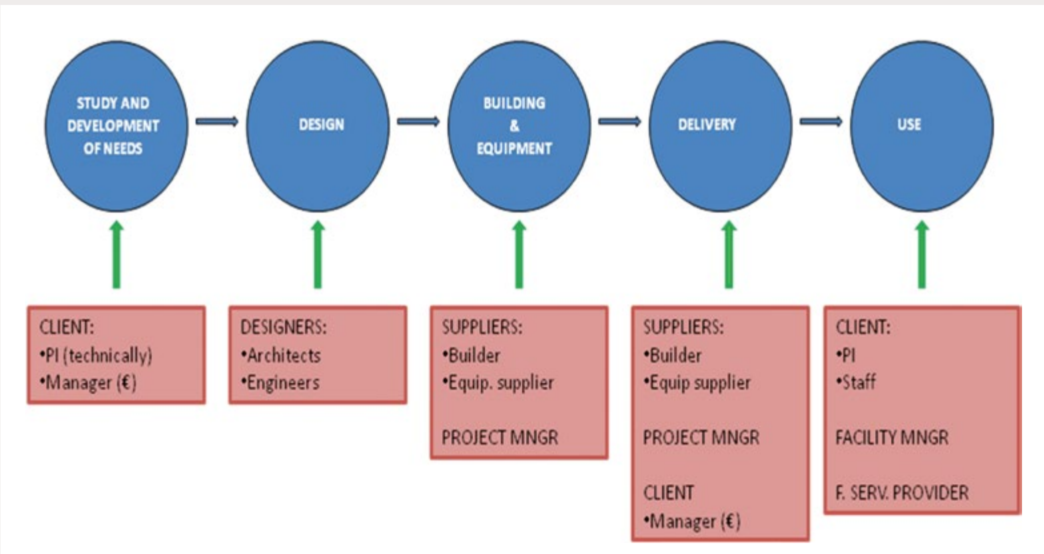

Fig. 2: Traditional approach for projects

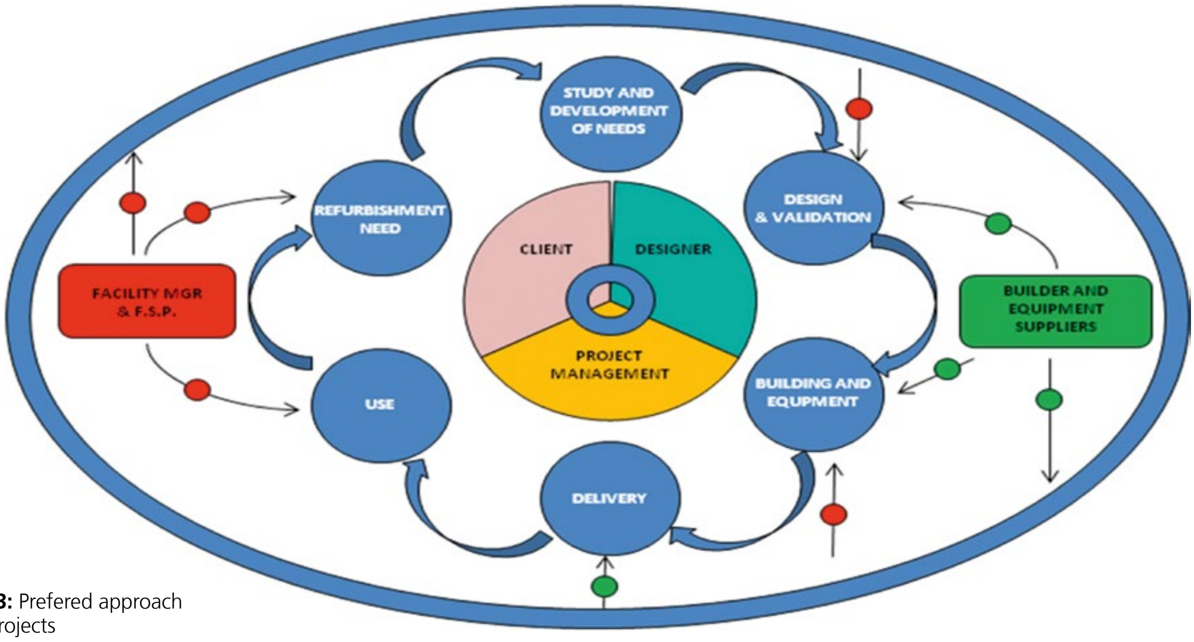

Fig. 3: Prefered approach for projects

over its lifetime. An integrated network must be considered, in order to facilitate the interconnection between participants and with a stable core group which makes it all possible.

EGNATON WG4 advocates an integrated model which takes the input of all stakeholders into consideration whenever necessary regardless of their time of participation under contract, to ensure sustainable management of resources along the life cycle of the laboratory building. ■

Considerations to be taken to reduce the negative of Manufacturing Laboratory Equipment impact on Sustainability

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Ecobalances or Life Cycle Assessments (LCAs) are becoming increasingly important in the environmental policy of the European Community. Most of all the laboratory world and the corresponding highly technical buildings and facilities with multiple functions, can and should play a leading role here. Modern research equipment and devices must be operated to meet the requirements of sustainability, while in the end, it is primarily in the lab where sustainable products are created and developed. Analysis and quality assurance are necessary to secure repeatedly sustainable properties, i.e. without laboratories, we cannot implement sustainability.

The known properties of laboratory equipment, such as the tolerability of aggressive chemicals, need to also be made sustainable. Scientists and lab users play a key role in the value chain of the socio-technical system laboratory (Figure 1).

To develop sustainable practices, processes and substances, the laboratory requires a sustainable environment. This consists of a building (technical building), equipment and devices. The development cycle of a research objective must therefore begin with sustainable circumstances especially in the initial phase in the laboratory. In this respect, laboratory equipment is of special importance in this regard. To meet the requirements, they must be formulated and structured in a transparent and consensus-like process. Sustainability is too important to allow them to deteriorate behind slogans and marketing strategies. Only when industry, in conjunction with planners and users, provides transparent and comprehensible industry regulations, will consumers derive confidence and take into account the marked products as sustainable in its procurement process. How should a set of rules of sustainability in general and in particular look for laboratory equipment to earn recognition of all stakeholders? In Europe, traditionally, long term behavior manifested by terms of resource conservation, energy saving and work safety has prevailed. In this respect the way to a sustainable future is not very far.

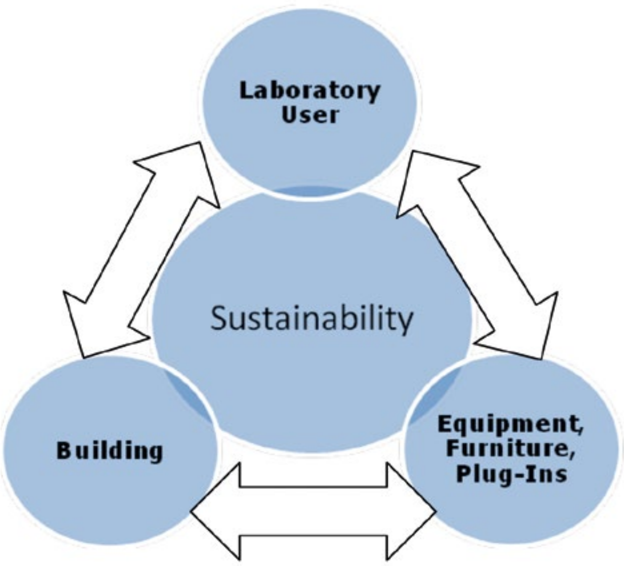

Fig. 1: Socio-Technical-System Laboratory

We distinguish between companies and products. The system follows the same rules apply in both cases.

Companies and Production

Just as the researcher can achieve sustainable results in a sustainable laboratory applies in the same way to manufacturers of sustainable products, so that their production should be sustainable organized. There are numerous environmental certifications and standards (EMAS, ISO 14001, etc.) that describe in a more or less clear way, especially environmentally friendly management and production, but without on one hand being mandatory and on the other hand assessing the degree of compliance with the rules. It is to be taken into account that compliance with environmental standards is not the same as sustainable production. This includes standing in mutual balance economic factors, socio-cultural aspects, technical and process quality.

Measures to be taken in production include, for example:

Hard factors

- Cut minimization in particleboard production using CNC milling or similar, i.e. waste minimization.

- Appropriate waste disposal, such as self-generation of power from combustible waste, which of course is to be dictated by prevention of emissions, etc

Soft factors

- Economical production
- Extensive local sourcing
- Compliance with all safety regulations
- Logistics optimization
- No child labour in the supply chain
- Supply chain adhering to the same rules as their own company
- Compliance with all social standards, etc.

Products

Primarily a resource-efficient design and production is promising. Again, there are accepted rules and standards, such as RoHS - 2011/65/EC directive (Reduction of Hazardous Substances) or REACH (Regulation (EC) No 1907 /2006). Balance can be safely assured by the product development based on the characteristics of the EGNATON CERT initiative[1].

Development of sustainable laboratory equipment needs clear intra-corporate design guidelines – e.g. Cradle to Cradle – by considering the effects, especially of the following use and re-use phases, in the production of the product. The sustainability package includes life cycle cost, socio - cultural aspects, such as safety and comfort, and of course ecological qualities. When selecting suitable materials and energy consumption it is clear that the effects of environmental consideration are not sufficient. There is always the suitability, compatibility, ergonomics and interactions with respect to all columns of sustainability to calculate. Indeed this is a complex system, which is to follow a recognized validated algorithm; otherwise marketing claims of the manufacturers must be qualified.

Material

A core aspect of sustainability to be taken into account is the choice of materials. Scalable and comparable results can only be implemented by writing PCR (Product Category Rules) and downstream EPD (Environment Product Declarations). The procedures are clearly defined normative (e.g. EN 15804). Of major importance is the requirement to work with recognized providers. This ensures that the results are comparable and internationally recognized.

The Institute Construction and Environment commented:

"Why environmental product declarations?"

- Environmental Product Declarations form the data base for the green building rating. This is currently set in the new European standardization project „Sustainability of construction works ".
- Environmental product declarations are based on ISO standards and are therefore internationally coordinated. They are suitable as proof of environmental claims in public tender specifications.
- Environmental Product Declarations provide the relevant source of data by representing environmental characteristics of a product in marketing or sales."[2]

It must be added that the allocation of laboratory equipment to the cost groups 474 and 612 or 475 of the HOA[3] makes the availability of PCR and EPD of laboratory equipment and to some extent devices in public bidding processes within the BNB [Bewertungssytem Nachhaltiges Bauen des Bundes (in Germany)] necessary.

The organizational effort and cost incurred are likely to be significant for individual manufacturers, therefore in an initial phase, the installation of industry EPD is recommended.

The process is open to the results of the influence of competing materials, for example, wood versus steel versus aluminium, which are yet to be assessed.

Examples of individual Arrangements

Using the example of laboratory furniture manufacturing, here are some concrete arrangements that are appropriate to improving sustainability.

- Certified environmental management system across the supply chain
- Priority recyclable materials
- Refraining from the use of composite materials and combination (hybrid monster)
- Paint from completely solvent-free powder coatings
- Operating energy regenerated
- Sorting of waste
- Powder coating without solvents
- Certificates: ISO 14001 inter alia
- Short transport routes, preferably local suppliers

Dedicated Design Criteria for sustainable Fume Cupboards:

- Fume cupboards with day and night settings
- VAV pressure control, sash control
- Audio-visual display
- Aerodynamic and fluid dynamic optimization
- Motion sensors
- Clear operating instructions
- Presentation of the life cycle costs
- LED lights
- Maximum user safety in case of accident

Sustainability of Laboratory Facilities using a Manufacturer from southern Germany as an Example

Here we consider the sustainability of laboratory equipment and we focus on the materials from which the product is produced. Manufacturers of various materials are working to determine the energy consumption and the CO_2 emissions caused in the manufacturing of their product. Included, among other things, is the energy consumption of employees travelling to work, as well as transport routes from the supplier to the producer or processing company. Another important point is the recyclability of the final product.

The industry leader from southern Germany presents his laboratory furniture system mainly produced from wood and steel. Wood is a renewable and CO_2 neutral material. The main supplier for this also comes from southern Germany and has a travel time from about 20 km. Besides this, in the manufacture of laboratory equipment no composite or combination of materials used and all paints are made are completely solvent-free powder coatings.

Production in turn, includes aspects such as energy consumption of the plants, waste treatment, or safety. The wood waste from the production at our manufacturer is used for heating supply. An on-site photovoltaic system supplies the production with 7% of annual electricity consumption and the employees pay attention to sorting their waste.

Companies that deal with these aspects as our example of sustainable manufacture can provide customers with an SCC certification for occupational health and safety or the EN ISO 14001 certification for environmental protection.

How much Energy does a Lab use?

Compared to a conventional office, laboratory work consumes considerably more energy, mainly due to the safety-related ventilation for subject and building protection. Furthermore, due to the numerous materials required in the laboratory must be distributed and disposed of accordingly.

To reduce energy consumption e.g. Secuflow fume cupboards contribute well, since they can achieve energy savings of up to 30%. Intelligent laboratory control systems reduce energy consumption at times when the laboratory is not occupied.

Life Cycle of a Laboratory

A sustainable laboratory allows the customer to work permanently within it, or rather, to operate it. However, laboratories are often used for projects with an average term of three years. In addition, the lab technicians use various types of laboratory equipment whose replacement cycle is nowadays only three to five years. This means for the laboratory that facilities that flexible and modular design need to be considered. ■

1 See article from Egbert Dittrich

2 See web site of IBU e.V.

3 The overall performance of an architect or engineer in Germany corresponds with the fees for architects and engineers (HOAI) divided into phases. The HOAI allocates the phases a certain proportion of the total fee of the architect or engineer.

The Importance of Safety Cabinets for sustainable Laboratory Work

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Laboratories are places in which scientists investigate and develop sustainable substances and materials, processes and technologies for the future. Owners and the public expect solutions, which enable economical work while at the same time being ecologically safe, and providing the greatest possible working safety and optimum comfort and convenience criteria. Furthermore, innovative developments should involve controlled and stable processes and perform outstandingly. This goal orientation requires a high degree of affinity with the workplace and working environment, whose safety is a decisive prerequisite for sustainable laboratory activity.

Sustainability

Against the background of steadily increasing efficiency with simultaneous reduction in costs, including life cycle costs, sustainable laboratory research is becoming increasingly important. Saving valuable resources such as water and energy, chemicals and raw materials not only minimises operating costs but also preserves the environment considerably. Reductions in emissions into the atmosphere, soil and water reduce environmental impacts substantially. Not least of all, new types of technologies and process optimisation also contribute towards minimising or preventing the release of harmful substances into the environment.

Fig. 1: Laboratory with modern push-to-open safety cabinets

Fig. 2: Safety cabinet – system-tested solution for active storage

Safety as a Prerequisite for Sustainability in the Laboratory

Occupational health and safety undoubtedly plays an important role in the discussion on sustainability in the laboratory. Within the scope of these issues, aspects such as comfort, convenience and work satisfaction are now also becoming increasingly important. The requirements according to the relevant regulations and behavioural characteristics of the user are relevant especially in the design phase and during the development of safety cabinets.

Active and passive Storage

The storage of flammable liquids and solids, hazardous substances and chemicals is part of everyday laboratory work in all industries. It is regulated by various laws, for example, the storage of flammable liquids in the "Betriebssicherheitsverordnung" (German industrial safety regulations - BetrSichV) or the "Technischen Regeln für brennbare Flüssigkeiten" (German Technical Rules for Flammable Liquids - TRbF). Passive storage is the term used to describe storage whereby the substances are stored in their original packaging or tightly sealed, and their fumes do not usually escape into the atmosphere. Passive storage in safety cabinets is specified in detail in the TRGS 510 and TRbF 20 regulations (German Technical Rules for Hazardous Substances and Flammable Liquids respectively).

However, in practice, most storage is in fact active, for example, when substances have to be filled or transferred at the safety cabinet, when working with substances or waste materials arise, which have to be disposed of properly. Active storage therefore includes the storage of flammable liquids in transportable containers, which are used in their place of storage as stationary, removable or collection containers or are opened for other purposes (TRbF 20, section 2.1.6).

Apart from fire safety, far-reaching safety measures are now required. In particular, the increased escape of fumes and the resulting increased risk of potentially explosive mixtures require appropriate solutions. In view of increasingly higher requirements of modern facility management, users and owners face new challenges with regard to the versatility and user comfort & convenience of safety cabinets.

Guidelines

According to these criteria, therefore, specific safety cabinets are required not only for active storage but also for passive storage, which take into account the relevant guidelines and regulations. However, in daily laboratory routine, changeovers from passive to active storage are not clearly defined, which often leads to the choice of the necessary safety cabinets to be used are therefore, whether consciously or unconsciously, unfortunately made very flexibly and frequently on the border of legality. According to the law, however, a differentiation must be made between active and passive storage and the corresponding safety cabinets to be selected, in order to enable liability issues and responsibilities to be clarified clearly in case of a fire or other disaster. For example, it is not permissible for a safety cabinet for passive storage to be drilled into by owners or users in order to subsequently install collection funnels for solvent wastes. On the other hand, it is permitted to work in a fume cupboard above a safety cabinet for passive storage (Fig. 1) and to take sealed containers out of the cabinet, in order to open them and further process their contents in the fume cupboard. In case of doubt it is advisable to develop appropriate solutions with the involvement of expert help.

Fig. 3: Funnel connection at safety cabinet for active storage

Fig. 4: Connection option for HPLC

Safety Solutions
Modern safety concepts include active and passive storage. With the new TÜV type-tested DISPOSAL-UTS ergo line, a special equipment entity for the laboratory has been created. Different types of specialised safety cabinets for active storage options have been developed to serve all kinds of requirements and work processes (Fig. 2). In order to ensure safe filling and transfer, all models of the cabinet range for active storage according to the relevant TRbF 30 and TRGS 526 regulations (laboratory guidelines) have optimised ventilation and enhanced earthing.

Industrial (forced) Ventilation
The effectiveness and control of the exhaust air is an important aspect of compliance with the explosion protection concept. In the case of active storage, safety cabinets must be connected to industrial or forced ventilation and must be monitored. The new safety cabinets have efficient air ducting with an increased exhaust air flow rate, of which it's tripled effect increases ensures safety. The building's extraction system removes fumes and harmful substances and fumes, which can be produced when transferring substances at the collection container both safely and reliably, directly at the source. At the same time, as the second stage of the safety package, the extraction of the entire cabinet interior comes into play. In addition, all bases are equipped with permanent floor extraction with front exhaust discharge slits. With the connection of the exhaust air, fumes and harmful substances which collect at the bottom, are picked up safely and added to the exhaust air. The ventilation function is also monitored by the standard integrated exhaust air monitoring unit. In the event of a reduction in pressure or ventilation failure an acoustic error signal is emitted.

Earthing
Earthing continuity or equipotential bonding is necessary to comply with the explosion protection requirements for active storage. Therefore, all surface coatings of the safety cabinets, inside and outside, as well as the attachments and installations, are designed to be electrically conductive in accordance with TRBS 2153 and BGR 132. The cabinet is connected to the building's earthing system via equipotential bonding saddles.

Level Control
Depending on the requirements profile of the work processes, it is possible to develop special, individualised system solutions

Fig. 5: Automatically extending pull-out trays

Fig. 6: The Toe-Kick base enables upright, back-friendly working and avoids bumping your feet.

for safety cabinets. Examples of these are built-in funnels or benchtop inlets for the collection of HPLC wastes (Fig. 3 and 4). Protection against overfilling of the collection container in the safety cabinet is an important part of the safety concept. The modular protection system, MPS, emits an acoustic warning signal if there is a risk of overfilling. Alternatively, a radio analysis option is also available.

Access Control

The MPS also includes a locking system function. For intelligent protection against unauthorised access, the door is unlocked via an RFID user card and is locked automatically by way of time control.

Handling

The new convenient push-to-open wing door technology and the automatically extending pull-out trays (Fig. 5) enable easy access to the stored liquid media and simple changing of the canisters. The stopcock is made drip-free to protect against unnecessary soiling when changing the canisters. Fast access to the stored hazardous substances is possible with a one hand movement. The system offers an optimum overview and closes automatically via a thermal trigger in the event of fire.

Ergonomics

In constructional terms, the Toe-Kick base enables ergonomic and back-friendly work. The cabinet no longer has a flush front; the 85 mm high base is set back by 50 mm, which provides sufficient clearance to prevent users from hitting their feet against it. It is now possible to work closer, more stable and more comfortably at the new UTS ergo line (Fig. 6). A castor set is available for all base variants, with which the safety cabinets can be easily installed or re-installed in the existing laboratory fitout (Fig. 7).

Fire Protection

In case of fire, the UTS ergo line series, safety cabinets are type-tested to EN 14470-1 ensure 90 minutes' fire resistance. The model range has also been awarded the TÜV Süd High-Quality Seal for top design and workmanship standards, usability and increased life. Not only the type certificate but also the associated explosion protection document is important for comprehensive hazard analysis.

Only a safe Workplace is sustainable

The "Betriebssicherheitsverordnung" (German industrial safety regulations - BetrSichV) require each employer to carry out a hazard assessment of their work equipment. Apart from the health and safety laws and TRbF 20 Annex L, a large number of additional regulations must also be taken into account in the laboratory. Tested and certified equipment and products simplify the necessary documentation in sustainable quality and environmental management. Reliably creating a safe workplace with individual design options is essential for sustainable laboratory work and indispensable for the social competence of owners.

Conclusion

Only a safe workplace in an ecologically and economically orientated working environment is sustainable. In the context of user behaviour it is the prerequisite for functional and goal-orientated work in the laboratory and for future-compliant developments. Safety equipment and safety cabinets in practice make an important contribution towards sustainable laboratory work. Certified products simplify time consuming documentation in the monitoring. With accredited system solutions, DUEPERTHAL offers a safe and reliable foundation for modern risk management. ■

Fig. 7: Set of castors on safety cabinet for maximum mobility

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Sustainability in Animal Laboratories – A Wish or Reality?

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Laboratory animal science is currently in a transition phase towards more sustainable operations. Over the past decade "Green" issues have moved into the mainstream of governmental, social and organizational concerns. Green issues – essentially conservation of non-renewable resources, reduction of waste and avoiding pollution – are an increasing focus of laboratory animal facility design and operations.

Research organizations consume significant amounts of energy, materials and generate considerable waste. The increasing influences of social responsibility and, in the EU, regulations are driving research organizations to reduce their energy consumption and the environmental impact of their operations. To minimize these impacts, it is necessary to introduce policies that reduce the use of energy and other resources while supporting efficient operations. Reducing the environmental impact of animal facility by sustainable operations is a new challenge and requires considering the "whole life cycle" environmental costs of a product or services.

The justification for "greening", or sustainable laboratory operations, is related to the impact of research laboratories on many different environmental, human health & safety and social factors .The current challenge is to reduce the volume of waste and also conserve resources by recycling or reusing non-hazardous waste products.

An international survey of facility managers discovered a growing interest in the sustainable operation of animal facilities and in taking action to reduce the impact of facility operations (Tab. 1).

From the survey it appears that Facility Managers are very sensitive to proposals and ideas from the market that can help them implement "Green Strategies". The Italian market leader in the Lab Animal Industry in designing, manufacturing and distributing patented equipments for laboratory animal housing since 1949 has the most complete product portfolio of the industry, ranging from open cages, IVC cages and bio-containment systems (IVC = individual ventilated cage), laminar flow work benches, rack-, cage and bottle washers, automated bedding handling systems, bedding disposal systems, housing systems for aquatic species like fish and frog, IVC monitoring and RFID census solutions to decontamination, automation systems and a complete range of accessories for the logistic within animal laboratories.

Has your facility implemented any of the following initiatives?	
Recycling	94%
Waste reduction	82%
Energy Conservation	82%
Switch from disposable to durable products	67%
Water conservation	75%
Use of renewable energy resources	38%
Improvements to Heating &Ventilation systems	41%
Improvements to lighting systems	75%
Science Associates Carbon Pawprint Survey	

Tab. 1: Growing interest in sustainable operation

Recycling of Plastic Materials

Driven by a genuine passion for innovation and against a background of increasing ecological awareness and growing concerns over global warming and climate change, in 2008 they implemented an ambitious scheme to encourage its customers to recycle their redundant plastic cages. Recycling redundant plastic conserves non-renewable fossil fuels, reduces energy consumption, the volume of solid waste going to landfill and emissions of carbon-dioxide (CO_2), nitrogen-oxide (NO), and sulphur-dioxide (SO_2).

The recycling program has been specifically designed to promote awareness of the costs and impacts of energy consumption in the Research Vivarium Industry and to support people looking to take action both in energy saving and in reducing emissions and waste.

Old redundant plastic cages and plastic components (Fig. 1) are shipped to a local plastic shredding facility, through a worldwide network established by the manufacturer. This minimizes the distance from the user to recycling centre and the amount of CO_2 footprint produced by transportation. After shredding (Fig. 2), the recycled plastic material is used to produce automotive parts, furniture and other urban equipment, offering a "second life" for the plastic.

The program involves today 70 customers in 5 different continents saving more than 2000tons of CO_2 emissions. A life cycle analysis (LCA) peer reviewed calculation estimated 20kg of CO_2 saved per kg of plastic ("Plastic Cage Recycling program at Helmholtz Centre Munich – Lab Animal Europe Vol. 10, n. 4 April 2010 36-37).

The Department of Comparative Medicine, Helmholtz Centre, German Research Centre for Environmental Health in Munich was one of the first customer organizations to participate in the TP plastic recycling program. Thanks to the program the centre was able to reduce plastic waste and CO_2 emissions by recycling redundant polycarbonate (PC) cages components

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Tecniplast implemented an enviromental policy almost a decade ago to reduce the environmental impact of its activities at all stages of the product life cycle: production, use and recycling. Tecniplast has taken into account three criteria that match external certifications (ISO 14001, Environmental Report) and objectively measurable data (emissions of CO2, LCA and quantity of recycled plastics via specific initiatives).

Production is carried out in an ISO 14001 certified factory. This certification attests to the efforts deployed to reduce the impact of production on the environment. It concerns, for example, reducing the use of water resources and energy, but also visual and sound pollution, emissions into the atmosphere and wastewater.

CO2 Emissions. Tecniplast products are the only ones which can offer customers a statement of CO2 emissions through a peer reviewed LCA analysis.

Recycling: Tecniplast products are designed to allow the exploitation of 100% of their mass at the end of the life (recycling and energy recovery). Moreover, Tecniplast offers an exclusive project of recycling old plastic cages for a second life to plastic and do something together for the environment.

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and plastic water bottles into material for new products. The recycling program started in 2008 and over a 15 month period the Helmholtz Centre collected more than 3,500kg of polycarbonate. The program saved a net total of more than 69.000 kg of CO_2 (after deducting the CO_2 produced by transport and recycling). For this initiative the Helmholtz Centre received the US Green Vivarium Foundation Award in 2009.

Energy Efficient Equipment

Facilities consume significant amounts of energy, to operate the housing systems for animals day and night, 365 days a year, to keep them safe and clean within the bio-containment. Facility managers, planners and building departments should consider selecting energy-saving technical equipments for their operations and products where the environmental impact (considering the Life Cycle Assessment) is as low as possible. The market leader has developed IVC-air handling units and laminar flow cage changing stations, where already many recyclable materials are used and new modern energy-saving components (e.g. DC motors/blowers) are selected, which can save up to 60%* of electrical energy as well as up to 60%* of heat dissipation into the laboratory rooms (*comparison of earlier air handling unit "super slim line" vs. new and modern types "easy/smart flow").

State of the art ventilated cage technology with a direct connection to the HVAC exhaust system makes it possible to reduce significant the air changes per hour (ACH) in the animal rooms, subject to the heat dissipation of the equipment, the animals and the operators have to be properly considered and calculated by the planners, before defining the final Air changes within the facility. All these aspects can have a direct impact on the required air volumes and sizes of the air conditioning systems and should be considered during designing of new facilities.

Equipment, Sanitization and Decontamination

A variety of equipment and other accessories within animal laboratories need to be routinely cleaned and sterilized to maintain a high level of hygiene. Many older washing machines and autoclaves were not designed to conserve energy, steam or water and can be costly to the environment and facility operations. Modern sanitizing and decontamination equipment is designed to reduce the energy, water and steam consumption of these processes while maintaining or improving the hygiene process. Recirculated washing processes with a powerful mechanical action and low chemical dosing concentrations remove soil effectively, fast and gentle from the surfaces. Maximizing the throughput with fast and energy efficient cycles, e.g. water consumptions of less than 0,6liter* or electricity of 0,005kWh* per cage per cycle can be achieved.

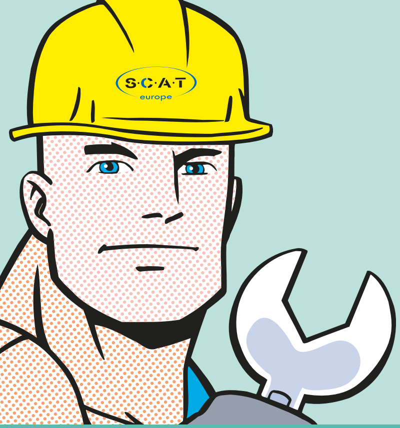
Waste Management, Waste Animal Bedding

The regular disposal of large amounts of waste animal bedding to landfill or incineration raises concerns involving operating costs, storage and transport, occupational health and safety risk and environmental impact. Depending on the size of an animal facility more than 1ton of bedding may disposed of each

Fig. 1: A plastic cage at the end of its life cycle, unusable due to loss of transparency after many autoclave and wash cycles.

Fig. 2: A plastic Shredder machine which grinds the old plastic cages to offer a second life to the plastic material as automotive parts, furniture and other urban equipment.

Fig. 3: A typical plastic cage with dirty bedding material and residuals from animals.



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week. Waste bedding can be incinerated, and this can have a serious enormous environmental impact. Heating systems operated with wooden pellets or wood chips use approx. 2kg of wooden pellets (depending of the quality and humidity) to generate 10kWh of heat. In comparison 1liter of oil required to achieve the same heat.

The manufacturer in collaboration with universities and specialists of briquetting systems, initiated studies on re-using waste bedding materials within animal laboratories for heat or energy generating. Pre-treatment of the waste bedding material (Fig. 3) requires shredding to a uniform size, conveying with special pneumatic bedding handling systems and briquetting the wooden chips (Fig. 4). The results of achieved heat gain in kWh/kg are very promising in comparison to industrialized wooden pellets or oil. Depending on the type of bedding material, the heat gain can raise up to 0.47kWh/kg of bedding. Tecniplast has now developed some special devices to offer a technical solution to prepare the bedding for incineration. Reusing of waste bedding material in laboratory animal laboratories could reduce operating costs, energy consumption and environmental impact and is be very powerful for future and be considered for new facility designs.

The sustainability program set itself these objectives, of which the most important is to support customers in limiting their carbon foot print. They aim to be a major driving force in the industry with its complete environmental campaign which deals with environmentally supportive behaviour in various everyday situations in a lab animal facility.

The above mentioned approach demonstrates that with a little thought and just a few resources, it is possible to make a big difference and make "sustainability" a reality in animal laboratories. ■

Fig. 4: Cage waste bedding now compacted as a briquette before disposal or incineration.