# *NatVent*™

*Overcoming technical barriers to low-energy natural ventilation in office type buildings in moderate and cold climates*

#M378

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# Barriers to Natural Ventilation Design of Office Buildings

## National Report: *Switzerland*


SULZER INFRA

**Sulzer Infra Lab AG**

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# Contents

# Introduction

The objective of the study described in this report is to identify barriers restricting the implementation of natural or simple fan assisted ventilation systems in the design of new office type buildings and in the refurbishment of existing such buildings. The perceived barriers are identified in an in-depth study with structured interviews based on questionnaires among leading designers and decision makers. The interviews have focused on general knowledge, viewpoints, experience and perceived problems with natural ventilation in office type buildings and on the decisions actually taken in specific building projects.

Mechanical ventilation systems are often installed in office buildings where good natural ventilation would have been sufficient to obtain comfortable indoor climate and good air quality. It is important to identify the barriers seen by designers and decision makers which restrict the implementation of natural ventilation systems and lead to the decision to install mechanical ventilation plants in office buildings where it is not strictly necessary. Knowing the barriers is the first step in providing solutions to overcome them. To our knowledge it is the first time a study of this type has been performed in Switzerland.

The identification of perceived barriers to natural ventilation design of office buildings is the first phase (work package) of the ***NatVent™*** project being carried out under the JOULE programme. The two other work packages in the ***NatVent™*** project are:

- Performance of naturally ventilated buildings.
  The aim is to evaluate the performance of twenty existing buildings designed specifically for natural ventilation.

- 'Smart' technology systems and components.
  The aim is to develop systems, components and solutions to the barriers and shortcomings identified in the first two work packages. This work package includes:
  - Air supply components suitable for high pollution and noise loads
  - Constant (natural) air flow inlets
  - Advanced natural ventilation systems with heat recovery
  - 'Smart' components and 'intelligent' controls for night cooling
  - Integration of 'smart' systems for year-round performance

The ***NatVent™*** project is performed by nine organisations in seven central and north European countries. The project is headed by Building Research Establishment, BRE (UK). The other partners are:

Centre Scientifique et Technique de la Construction, CSTC (B)
Danish Building Research Institute, SBI (DK)
TNO Bouw (NL)
AB Jacobsen & Widmark, J&W (S)
Technical University, Delft (NL)
Willan Building Group (UK)
Norwegian Building Research Institute, NBI (N)
Sulzer Infra Lab AG (CH)

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This report describes the results of the Swiss interviews. Similar reports giving the results of the interviews in the other countries are also produced.

In addition the main results of the interviews will be published in a common final international report. The final report will summarise the results from the interviews in each country and compare them to identify common problems with the implementation of natural ventilation systems and to gain experience from countries that have solved some of the problems. The final report will also give recommendations on how to overcome the identified barriers.

The ***NatVent™*** project team would like to thank all the interviewees: designers and decision makers for the knowledge and experience they have brought to the project and for the time they have spend.

# Method

The perceived barriers to natural ventilation design of office buildings are identified in an in-depth study with structured interviews among leading designers and decision makers: architects, consulting engineers, contractors, developers, owners and the governmental decision maker responsible for regulations and standards.

Interviews with ordinary users of office buildings are not included in this study, because they are not the ones making the decisions in the design phase. The users perception of the indoor climate is part of Work Package 2: 'Performance of naturally ventilated buildings', where physical parameters e.g. ventilation rates, room temperatures and indoor air quality are also measured and compared with the users responses.

The interviews consist of two parts:

- General view on natural ventilation in office buildings.
  This part focus on general knowledge, viewpoints, experience and perceived problems with natural ventilation systems in office type buildings.

- Specific building project.
  This part focus on the decisions actually made during the design or refurbishment of an office type building.

Both parts of the interview were in general performed with all interviewees. The only general exception is the interview with the governmental decision maker, where only the general view on natural ventilation in office buildings is relevant.

The interviews were performed among:

5 Architects
3 Consulting engineers
2 Contractors
2 Developers
2 Owners
1 Governmental decision maker (responsible for regulations and standards)

The number of designers and decision makers interviewed are limited due to limited financial resources in the project. The persons interviewed are therefore selected with the intention to also identify the variety in opinions and viewpoints on natural ventilation in office buildings.

The interviews were based on questionnaires. There were two questionnaires to be filled in during an interview. The first questionnaire covers: General view on natural ventilation in office buildings and the second questionnaire covers: Specific building project.

The questionnaires are designed to facilitate the performance of statistics on the viewpoint of the interviewee. The questionnaires are not too tight and there are ample space for additional comments, remarks and viewpoints not included in the questions.

The questionnaires were completed by the interviewee and the interviewer together and the interviewer also if necessary guided the interviewee in understanding the questions. If a question couldn't be answered by the interviewee or is irrelevant to the interviewee it was indicated in the questionnaire.

*Questionnaire on general view*

The questionnaire concerns general view on natural ventilation in office buildings. The questionnaire are reproduced in annex IV. The questionnaire comprises 14 subjects:

1. Interviewee
Identification of the interviewee

2. Organisation
Description of the organisation: type, disciplines, number of employees and building types.

3. Knowledge
Knowledge on mechanical ventilation, heat recovery, mechanical cooling, ordinary natural ventilation and special design natural ventilation in offices including special ventilation windows, advanced vents, internal ventilation openings, roof openings etc. The questions were answered by indicating the knowledge on a specific 5 point scale ranking from 'None' to 'Thorough'.

4. Experience
Ventilation experience in the organisation focusing on the extension of new and refurbished office buildings designed or owned by the interviewees organisation. Also questions to identify the percentage of buildings with: mechanical ventilation, ordinary natural ventilation and special design natural ventilation in the offices.

5. Project fee
Type of project fee received by architects and consulting engineers for the design of office buildings. Questions were asked to identify the percentage of projects with fee paid as: fixed fee, percentage of construction cost, per hour rate or other type of payment for design.

6. Natural ventilation in cellular offices
7. Mechanical ventilation in cellular offices
8. Natural ventilation in open plan offices
9. Mechanical ventilation in open plan offices
General views on perceived advantages or problems with either natural or mechanical ventilation in cellular and open plan offices. The questions asked under subjects 6, 7, 8 and 9 are identical and only the ventilation system and the office type differs. The questions concern: design, availability of products, performance in practice, controllability and costs and were answered by checking the same 5 points scale as used in subject 3.

10. Your source of natural ventilation knowledge
Possible sources are: standards, guidelines, building studies, experience, own design and other.

11. Expected future use of natural ventilation in office buildings
Expected future use of natural ventilation in office buildings designed or owned by the organisation. The question were answered by checking a specific 5 points scale ranking from 'Decreasing' over 'Unchanged' to 'Increasing'. The interviewees were also asked why they have this expectation.

12. Requirements restricting the use of natural ventilation in offices
Perceived restriction in the use of natural ventilation in offices from requirements in building codes, norms, standards, working condition codes etc. The question were answered by checking a 5 points scale ranking from 'None' to 'Comprehensive' and by indicating which code, norm or standard that includes the restrictions.

13. Desirable new design tools for natural ventilation
Possible new sources and design tools could be source books, guide lines, examples, simple or advanced computer programmes etc.

14. Desirable new components for natural ventilation
Possible new components could be air inlets, control systems etc.

## *Questionnaire on specific building project*

The questionnaire concerns one specific building project. The questionnaire are reproduced in annex II. The building could be either newly constructed or newly refurbished and could be with either natural or mechanical ventilation. The building were selected by the interviewee to be typical. The questionnaire comprises 5 subjects:

1. Interviewee
Identification of the interviewee

2. Building
Identification of the building and indication of key figures including building name, address, building type, year of construction, year of refurbishment (if any), site (urban, sub-urban, industrial or rural), $m^2$-floor area, number of storeys, building depth from facade to facade and storey height.

3. The design
Description of the actual design of the ventilation system and the building design parameters with influence on the ventilation demand and the ventilation system design. The design were described by checking a row of boxes for each room type in the building: offices, meeting rooms, canteen, corridors, stairways, entrance hall, atria, lavatories and others. The design specification includes:

| | |
|---|---|
| Ventilation system: | Mechanical ventilation, mechanical exhaust, natural ventilation, heat recovery, night time ventilation |
| Mechanical cooling: | In ventilation system, cooled ceilings |
| External openings: | Ordinary windows, special ventilation windows, ordinary vents, advanced vents, stack ducts, ventilation chimneys, roof openings, ducted air supply |
| Internal horizontal flow openings: | Doors, ventilation openings, open connection |
| Internal vertical flow openings: | Ventilation openings, open connection |
| Solar shading: | Internal, between panes, external, protective glazing |
| Ceilings: | High ceiling, false ceiling, exposed heavy structure |
| Floor and walls: | Exposed heavy floor, internal walls, external walls |

4. Background for the design
Indication of critical parameters in the ventilation system design and in the relevant parts of the building design. The critical parameters were prioritised for each of the room types on a 5 point specific scale ranking from '1. low' to '5. high'. The critical parameters includes:

| | |
|---|---|
| Winter conditions: | Room temperatures, indoor air quality, draught |
| Summer conditions: | Room temperatures, solar loads, internal heat, draught |
| Controllability: | Individual control |
| Noise: | Internal noise, external noise |
| Pollution and odours: | Internal air and external air pollution or odours |
| Safety: | Fire regulations, security |
| Costs: | Construction, operating and maintenance costs |

5. Biggest influence on chosen design
Indication of biggest influence on the chosen design. The influence could be from: architect, consulting engineer, contractor, owner, developer, investor, user, the actual building site, requirements in codes, norms,

standards or from other. The influence were prioritised on the same 5 point specific scale as used in subject 4 above.

# Results

The main results of the interviews are described in this chapter. Detailed listing of the statistics from the questionnaires are given in annex VI: Detailed statistics from questionnaires. A list of the interviewee's opinions, remarks and comments to the questionnaires are given in annex V: Interviewees opinions, remarks and comments.

## *The interviewee*

The five *architects* interviewed represent some of the leading Swiss architect offices. They have between 1 and 50 employees. They annually each design 1,000-15,000 m$^2$ floor area in new office buildings and 200-3,000 m$^2$ in refurbishment of office buildings. Most of them also designs other types of buildings e. g. schools, institutions, museum, housing and production buildings.

The three *consulting engineers* interviewed represents some of the largest Swiss consulting engineer offices. They have between 35 and 100 employees. They annually design 2000-40,000 m$^2$ floor area in new office buildings and 3000-40,000 m$^2$ in refurbishment of office buildings. All of them also design other types of buildings, plants and constructions.

The two *contractors* interviewed include the largest Swiss contractor. They have 100 and 5500 employees each and deal with all types of buildings and constructions. One contractor was not able to exactly specify the annually built floor area, because of the decentralised structure of the company with some seventy profit centres in several European countries. The other contractor has annually about 35 new and 5 refurbishment objects, without being able to specify the average floor area size. This quantity is valid only for the Swiss branch of its particular subsidiary. Again total numbers for the whole company are not available.

The two *developers* interviewed represents some of the largest Swiss contractors. The companies also acts as developers. They have a personell of 500 and 1000 workers each and deal with all types of buildings and constructions. One of them annually constructs a floor area of 100,000 m$^2$ in new office buildings. The interviewees were not able to specify the annual refurbishment floor area. The other annually constructs a floor area of 4,000 m$^2$ in new office buildings and 2,000 m$^2$ in refurbishment of office buildings.

Both *owners* interviewed are heads of the building services department of major Swiss insurance companies with 2500 and 4000 employees in total each and 50 and 80 respective in the building services department. They are responsible for 100,000 m$^2$ and 150,000 m$^2$ floor area each.

The *governmental decision maker* was from the authorities of Zürich city, well known for rather stringent but modern regulations regarding mechanical installations in buildings. He is a well known opinion leader in the field of building installations and energy consumption.

## *General view*

The two *developers* were very different in their general opinion on natural ventilation. One of the developers, mainly based in the Zurich area, would mostly install mechanical ventilation in new office buildings. The other developer claimed that ordinary natural ventilation would always be satisfying and there would be no need for mechanical ventilation in typical Swiss locations. Interestingly, the company is based in Zug 30 km south of Zürich, a city with some 60,000 inhabitants and hardly any heavy industry. Because of the moderate taxes, the city has recently become a very popular centre for trading and servicing companies.

The two *owners* represented similar companies, both located in urban areas, but completely different philosophies of building installations. While in one company 95 % of the floor area is mechanically ventilated, 70 % of the floor area of the other owner was naturally ventilated by simple window airing only.

The governmental decision maker is a physicist by training. The execution of the standards and regulation applicable for the city of Zürich lies in his responsibility.

The results in the figures in this section of the report are the average for each group of professions interviewed. If none of the interviewees in a profession group has answered a question, the result is omitted for that profession group and question. *All* are the average of all groups except the governmental decision maker, with the profession groups weighted equal. In case the governmental decision maker is included in the sum, it is referred as *All interviewees including the governmental decision maker (All & g.d.)*.

**Knowledge on ventilation**

Figure 1 shows the interviewees perception of own knowledge on the five topics: mechanical ventilation, heat recovery, mechanical cooling, ordinary natural ventilation and special designed natural ventilation. A specific 5 point scale ranking from 1: *None* to 5: *Thorough* is used to indicate the level of knowledge.

The interviewee have indicated their level of knowledge on the five topics based on the knowledge necessary to perform their normal task in the design or decision process and relative to their profession. As one of the architects expressed it: *'The architects design and knowledge on ventilation is in the general strategies and not on details'*. It is therefore not possible to compare the absolute level of knowledge between the professions based on the results. The results can merely be used to compare the relative knowledge on the five subjects group by group. The high overall reading of the developers compared to the other profession group is therefore not interpretable.

Almost all the interviewees have a lower knowledge on special designed natural ventilation compared to their knowledge on mechanical ventilation in offices. Exceptions are two of the architects who have a better perceived knowledge on special designed natural ventilation than on mechanical ventilation. Overall the difference in the perceived knowledge on natural ventilation relative to mechanical ventilation is the smallest in the architects group. The largest difference is found in the contractors group. Because this group is more involved in mechanical ventilated buildings than in naturally ventilated ones, this finding doesn't come as a surprise. Also for the consulting engineer group the knowledge split between mechanical and natural ventilation is quite pronounced.

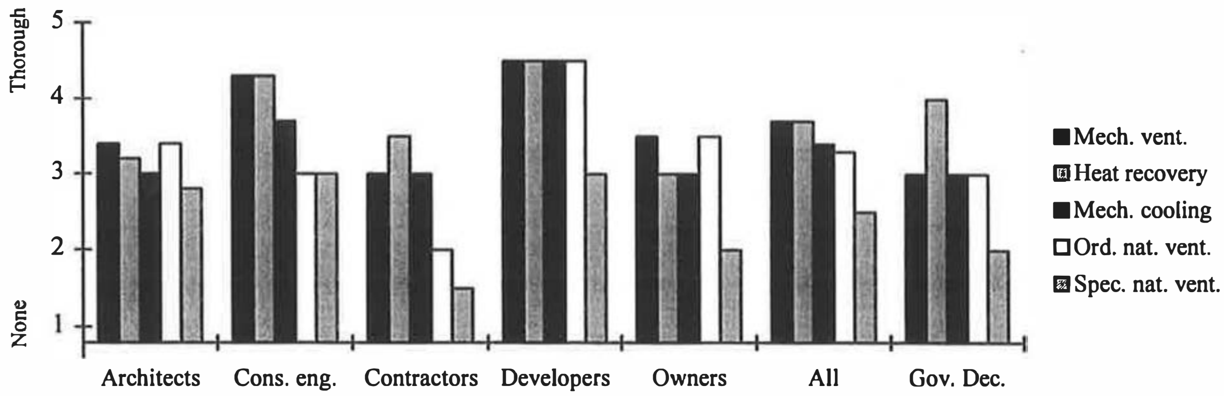


*Figure 1. The interviewees perception of own knowledge. The scale ranks from 1: None to 5: Thorough.*

## Experience

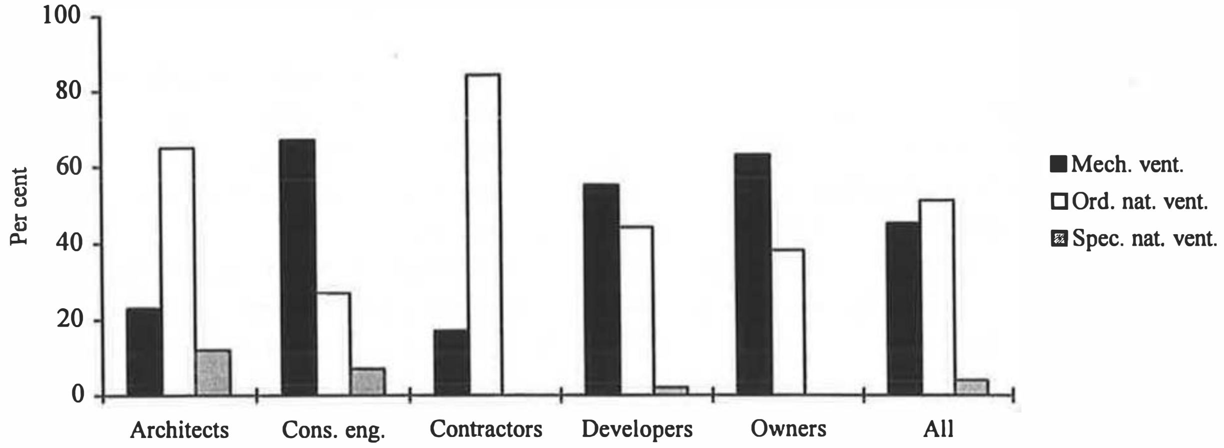


*Figure 2. The interviewees relative experience with mechanical and natural ventilation in new offices. The scale indicates the per cent of mechanical or natural ventilated new offices designed or owned.*

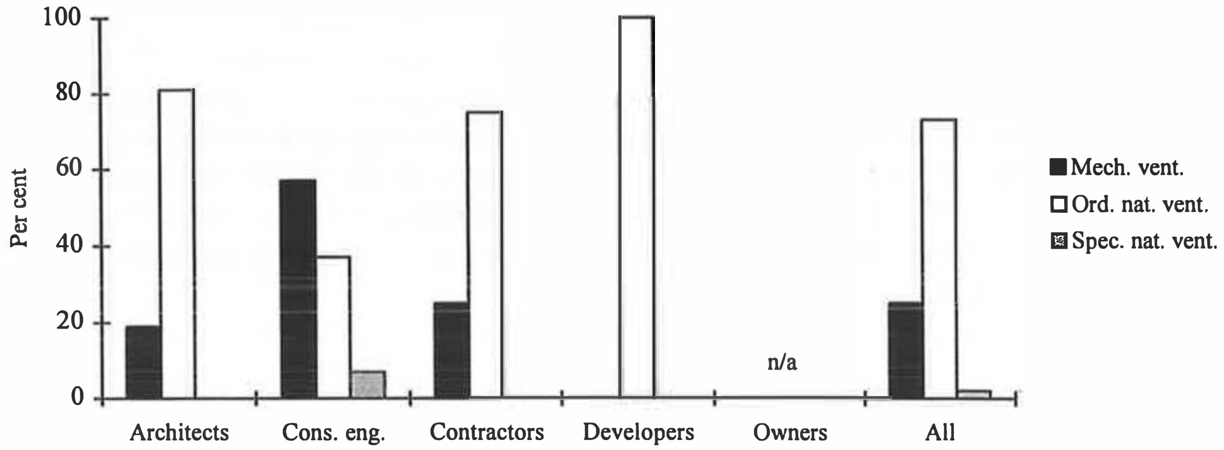


*Figure 3. The interviewees relative experience with mechanical and natural ventilation in refurbished offices. The scale indicates the per cent of mechanical or natural ventilated refurbished offices designed or owned.*

The interviewees relative experience with mechanical ventilation, ordinary natural ventilation and special designed natural ventilation in new offices is shown in figure 2. Figure 3 shows the interviewees relative experience with mechanical and natural ventilation in refurbished offices. The relative experience is the per cent of mechanical or natural ventilated offices designed, constructed or owned, measured by the floor area or alternatively by the number of office buildings.

The experience on ordinary natural ventilation and on mechanical ventilation in offices is high. Most of the interviewees have worked with both ordinary natural ventilation and mechanical ventilation in office buildings, but the actual number of buildings of each type designed or owned varies significantly. In refurbishment, ordinary natural ventilation is chosen more often than in new buildings. It was mentioned several times, that a the installation of ductwork in existing buildings is often not possible with reasonable costs. The surprising preference for natural ventilation of the contractor group originates from the fact that one of the interviewees is from company specialised on window automation. The other interviewed contractor was from a typical HVAC equipment installation and service company with correspondingly higher marks for mechanical ventilation.

The interviewees experience with special designed natural ventilated offices is very limited. Only a few of the architects, consulting engineers and developers have designed or invested in an office building with specially designed natural ventilation and none of the contractors and owners have constructed or are the owner of such a building.

**Project fee**

The type of fee received by the interviewed architects and consulting engineers for the design of office buildings is shown in figure 4. The possible fee types are: Fixed fee, percentage of construction costs and per hour rate.

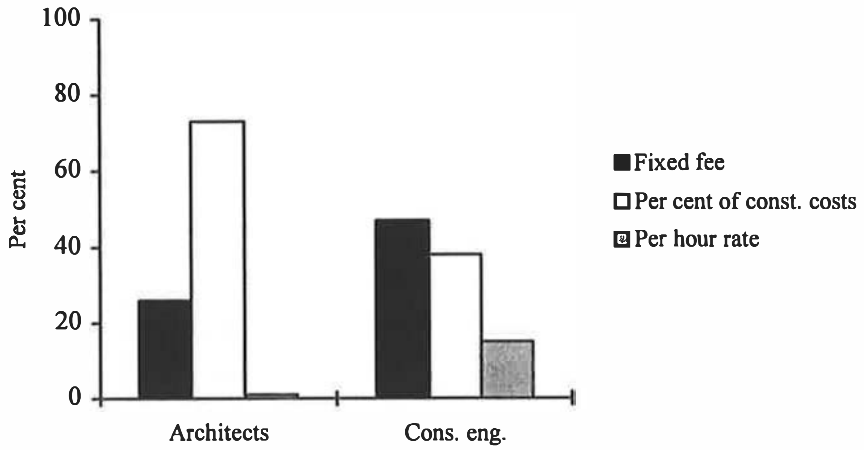


*Figure 4. Type of fee received by the interviewed architects and consulting engineers for the design of office buildings.*

Most of the interviewed architects and engineers are normally paid according to the design fee rules of the Swiss Counsel of Architects and Engineers (SIA). The rules foresee a fix price fee based on construction costs. Depending on the phase of the project, predicted or real construction costs are applied. The fee type definitions used in the questionnaire unfortunately don't comply with this normally used fee structure because it can be considered as both a 'fixed fee' and a 'per cent of the construction costs'.

The interviewed architects and consulting engineers are normally only paid by a 'per hour rate' in case of initial draft designs or small specific design tasks.

One of the building owner mentioned a new fee model they have successfully applied: Starting from a fixed fee for the architect based on the initial budget for the predicted construction costs, the architect's fee is increased proportionally to the amount the real construction costs remain under the predicted construction costs. The architect participates in this model directly on the owner's money savings. The quality level of the execution is defined in advanced and supervised by an independent quality control. With this fee structure relationship between the architect's fee and the construction cost is reversed.

**Design**

The interviewees perceptions (*all*) of the design of natural and mechanical ventilation in cellular and open plan offices regarding ease of design, availability of design guidelines and advises, availability of products, flexibility to building use and user satisfaction are shown in figure 5. A specific 5 point scale ranking from 1: *Poor* to 5: *Excellent* is used to indicate the interviewees perception of the design for the four cases

- Natural ventilation in cellular offices
- Natural ventilation in open plan offices
- Mechanical ventilation in cellular offices
- Mechanical ventilation in open plan offices.

With respect to ventilation, the interviewees perceived open plan offices to be more difficult to design than cellular offices. The increase in perceived difficulty with the room size was especially pronounced for the natural ventilated offices.

Several of the interviewees emphasised that the ease of design depends heavily on the complexity of the system e.g. whether it is a simple or an advanced natural ventilation system.

One of the architects mentioned that a successful design of advanced natural ventilation is only possible when the architect and the consulting engineer are together in a design team and closely interact. He stressed that the successful implementation of advanced natural ventilation relies on a whole suit of measures, each in agreement with the others.

Often the interviewees were suspicious about natural ventilation being strong enough to evenly ventilate an open plan office without causing any draughts. In general the increasing room size was identified as a problem for natural ventilation. The marks for the natural open plan offices were lowest throughout the five interrogated aspects. Interestingly enough, the room size (cellular versus open plan offices) is not perceived as a major influence for the design of mechanical ventilated offices. The marks for mech. cellular and mech. open plan offices do not differ significantly.

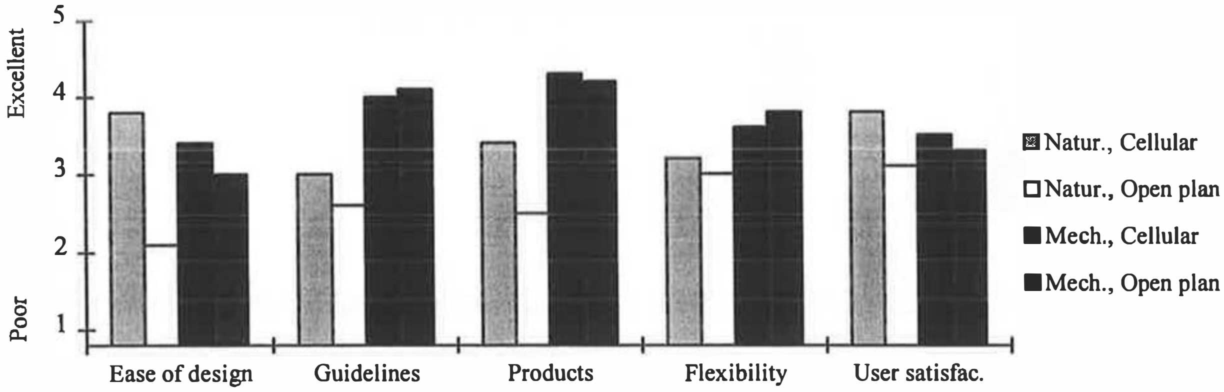


*Figure 5. The interviewees perception of the design of natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Poor to 5: Excellent.*

Nearly all interviewees found that the availability of design *guidelines and advises* and the availability of *products* are better on mechanical ventilation systems compared to natural ventilation systems. Again this lack was perceived more severe in the case of open plan offices than for cellular offices. One of the architects mentioned that it may not be the availability of the products itself but the knowledge about their existence and examples how they are successfully integrated into a whole system.
About design guidelines and advises on natural ventilation see also 'Source to natural ventilation knowledge' on page 15.

In general there are no significant different between the interviewees perception of the *flexibility* to building use in the four cases, the mechanical ventilation ranked slightly higher. It was argued by a consulting engineer that mechanical ventilation can handle higher heat loads than natural ventilation, allowing for a more flexible use.

In general the interviewees expect the same level of *user satisfaction* in natural and mechanical ventilated offices. The interviewees expect a little higher user satisfaction in natural ventilated cellular offices than in mechanical ventilated offices and a little lower user satisfaction in natural ventilated open plan offices than in mechanical ventilated offices.

**Performance in practice**

The interviewees perception of the performance in practice of natural and mechanical ventilation in cellular and open plan offices regard cooling effectiveness, draught minimisation, ability to remove odours and pollutants, ability to prevent ingress of odours and pollutants, insulation against external noise, generation or transmission of internal noise are shown in figure 6. A specific 5 point scale ranking from 1: *Poor* to 5: *Excellent* is used to indicate the interviewees perception of the performance in practice.

In general the interviewees expect a better performance in practice of mechanical ventilation systems than of natural ventilation systems with regard to cooling effectiveness, ability to remove odours and pollutants, ability to prevent ingress of odours and pollutants and insulation against external noise. Regarding draught minimisation and generation or transmission of internal noise they expect about the same performance in practice. According to the graph given below, no significant difference between cellular and open plan offices is perceived.

Several of the interviewees emphasised that the performance in practice also depends on the design of the system whether it is well designed or not. For answering the questionnaire, reasonably well designed buildings were assumed. Also the influence of the thermal mass of the building on the cooling effectiveness was mentioned.

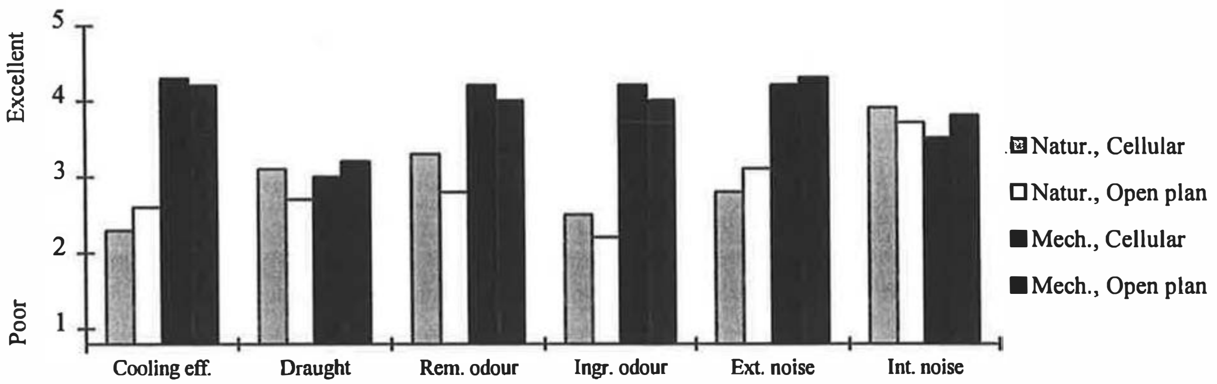


*Figure 6. The interviewees perception of the performance in practice of natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Poor to 5: Excellent.*

One of the owners admitted high summer temperatures in buildings with high natural ventilation. In general people understand under the term natural ventilation normal window airing buildings. More modern concepts are only known to a very limited range of people.
Compared with mechanical ventilation the overall performance of natural ventilation is pervceived to be lower. Nevertheless the user satisfaction in naturally ventilated buildings - as seen in fig. 5 - is at least as high as for mechanical ventilation.

**Controllability**
The interviewees perception of the controllability of natural and mechanical ventilation in cellular and open plan offices regard central controllability, local controllability (per office) and individual controllability (per person) are shown in figure 7. A specific 5 point scale ranking from 1: *Poor* to 5: *Excellent* is used to indicate the interviewees perception of the controllability.

In general the interviewees expect a high central controllability of mechanical ventilation systems and a low central controllability of natural ventilation systems. On a local level (per office) mechanical systems are still perceived to be a little more controllable than natural systems.
In cellular offices, the individual scale was assumed to be identical with the local level. Nevertheless, in comparison with local (per room) controllability the interviewees perceive a better individual controllability for natural ventilation and a worse individual controllability for mechanical ventilation.

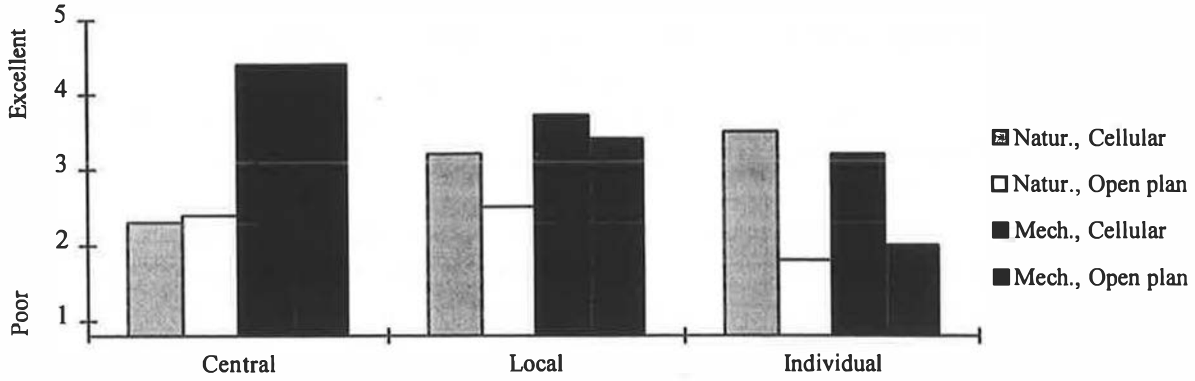


*Figure 7. The interviewees perception of the controllability of natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Poor to 5: Excellent.*

The expected individual controllability of the ventilation in cellular offices is higher than the expected individual controllability of the ventilation in open plan offices. The expected individual controllability of natural ventilated cellular offices is a little higher than the expected individual controllability of mechanical ventilated cellular offices. One of the architects emphasised the individual controllability being the main advantage of cellular offices.

**Costs**

The interviewees perception of the costs for natural and mechanical ventilation in cellular and open plan offices regarding installation costs, running costs and maintenance costs are shown in figure 8. A specific 5 point scale ranking from 1: *Inexpensive* to 5: *Expensive* is used to indicate the interviewees perception of the costs.

All interviewees expect both higher installation costs, higher running costs and higher maintenance costs for mechanical ventilation in offices than for natural ventilation in offices. Costs were mentioned several times to be one of the central factors in deciding between mechanical and natural ventilation, underlining the importance of this factor. In specifying the relevant costs, typically life cycle costs for the first five years were mentioned. Predicted money savings at a time later than five years are not that interesting for the investor anymore, to influence the design.

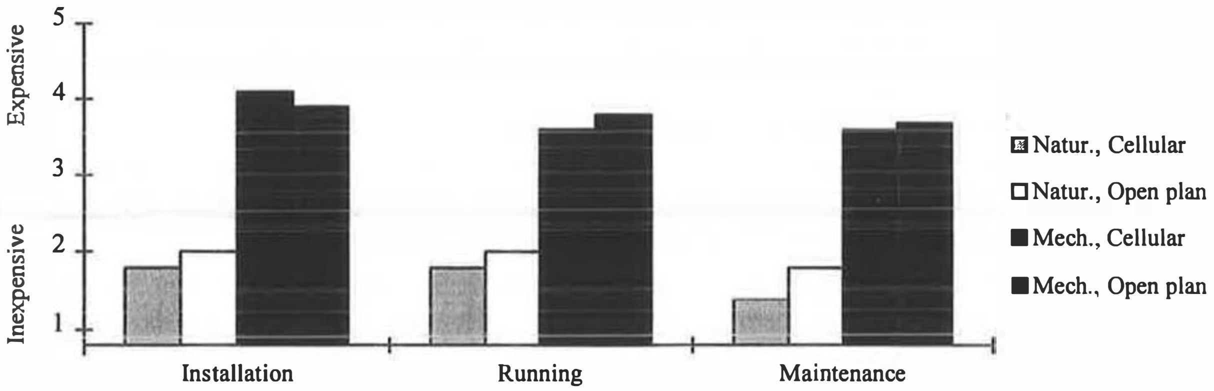


*Figure 8. The interviewees perception of the costs for natural and mechanical ventilation in cellular and open plan offices. The scale ranks from 1: Inexpensive to 5: Expensive.*

**Source to natural ventilation knowledge**
The interviewees sources to natural ventilation knowledge with regard to standards, guidelines, building studies, experience, own design and others are shown in figure 9. The scale is the per cent of interviewees using a source type.

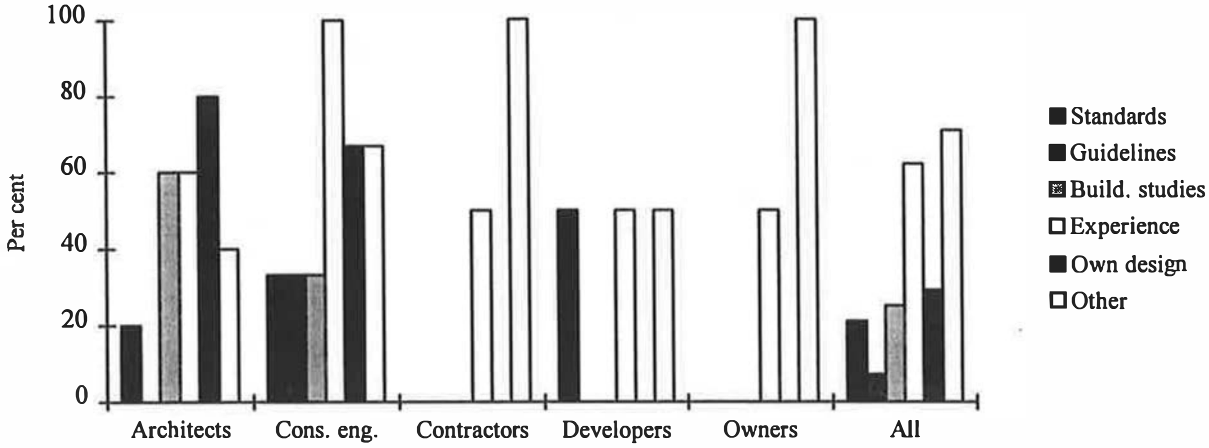


*Figure 9. The interviewees source to natural ventilation knowledge. The scale is the per cent of interviewees using a source type.*

The general opinion among the interviewees is that there is huge lack of good sources to natural ventilation knowledge. The mentioned sources are very sporadic and nearly no specific source were mentioned by more than one or two of the interviewees. The mentioned sources to natural ventilation knowledge are:

- National periodicals
- International periodicals
- Traditional architecture
- Intuition
- Lecture meetings in professional societies, symposia, conferences
- Physics, thermo- and aerodynamics

**Expected future use of natural ventilation**
The interviewees expectations on the future use of natural ventilation in offices are shown in figure 10. The expectation is indicated on a specific 5 points scale ranking from 1: *Significant decrease* over 3: *Unchanged* to 5: *Significant increase*.

The architects have the highest expectations of an increase in the use of natural ventilation in offices. The three consulting engineers and the two developers have expectations on either unchanged or moderate increasing use of natural ventilation in offices. Both contractors and owners expect a slowly increasing use of natural ventilation in offices. Only the governmental decision maker expects a significant decrease in the use of natural ventilation in offices. He believes that in our climate mechanical systems with integrated heat recovery have a higher energy efficiency than natural driven systems without heat recovery.

Typical reasons mentioned by the interviewees for expecting an increasing use of natural ventilation in offices are:
- Energy consumption is a key question
- Lower costs (investment and running costs)
- A wide public is sensitised for environmental issues (in Europe)
- Better perceived indoor climate
- Lower costs
- Better perceived comfort

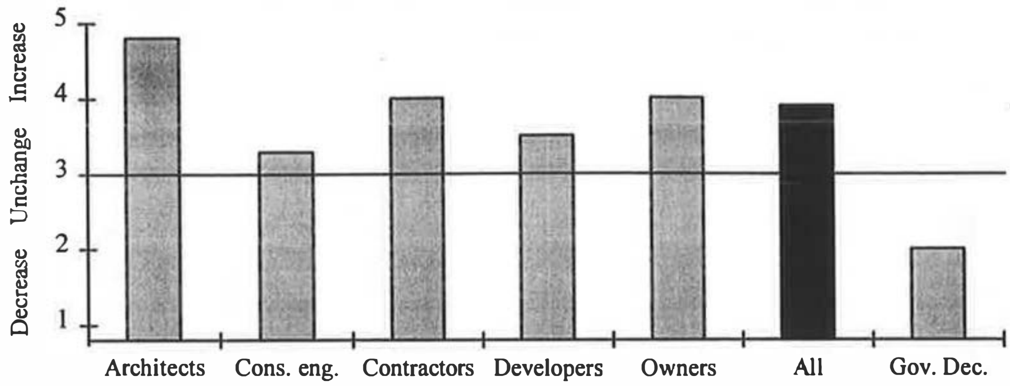


*Figure 10. The interviewees expectations on the future use of natural ventilation in offices. The scale used ranks from 1: Significant decreasing over 3: Unchanged to 5: Significant increasing.*

Typical reasons for expecting unchanged use of natural ventilation in offices are:
- Most of the office buildings in Switzerland already exist. In refurbishment it is usually quite difficult to fundamentally change the ventilation concept of a building.

Typical reasons for expecting decreasing use of natural ventilation in offices are:
- Problems with integration of heat recovery
- Lower overall energy efficiency

**Restricting requirements in codes**

The interviewees perception of requirements in building regulations, codes, norms and standards restricting the use of natural ventilation in offices are shown in figure 11. The architects but also the consulting engineers feel the requirements originating from the codes and regulations to be much more stringent than the issuing governmental decision maker feels.

A concentrate of Swiss regulations, codes, norms and standards related to natural ventilation or simple fan assisted ventilation systems in offices is given in annex II: 'Requirements in codes related to natural ventilation'.

Restrictions to the use of natural ventilation in offices mentioned by the interviewees:

- Fire regulations limit the size of open spaces within the building i.e. atria.
- Working environment code: Windows of office buildings have to face the outside. Windows facing an atrium need a special permission.
- Fire regulations; all the standards have been designed in view of mechanical ventilation. The way is regulated instead of specifying the target, no matter how it will be achieved.
- Guidelines should be target oriented, not parameter oriented.
- Technical restrictions, laws
- In restaurants mechanical ventilation is compulsory.
- From a certain ventilation level on, heat recovery becomes compulsory.

- Requirements in the standards are designed to meet also extreme (limiting) cases and are too high for typical every day applications.

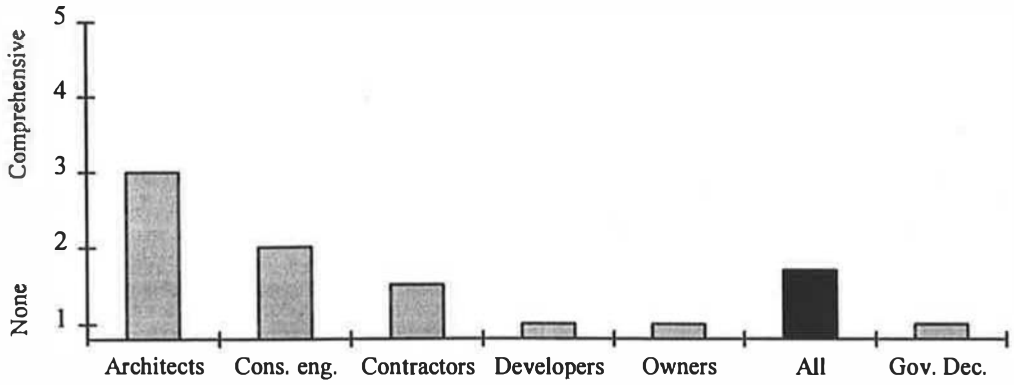


*Figure 11. The interviewees perception of requirements in building regulations, codes, norms and standards restricting the use of natural ventilation in offices. The scale ranks from 1: None to 5: Comprehensive.*

**Desirable new design tools**

The desired new design tools for natural ventilation mentioned by the interviewees depends on there proficiency.

In general the interviewed architects desires:

- Better guidelines,
- Collections (books, periodic reviews, on-line internet database) with realised well documented examples with long term performance evaluation
- Tutorial books
- Basic information and design tools
- Simple computer tools
- More refined computer programmes with the possibility of simulating a broader choice of building materials.

The interviewed consulting engineers desire:

- Market screening on available products and systems
- Reported neutral experience with the usage of components on the market
- Simple computer tools
- Combined tools: energetic and perceptive (draughts, smells, noises, temporal variance) optimisation of HVAC systems)
- Design guide lines, guide lines how to design naturally ventilated open plan offices.

The interviewed contractors and developers would like to have more well documented examples of buildings with advanced natural ventilation. Besides explaining the key principles and features of the building, they would also like to see some monitoring data included.

One of the developers mentioned first that he would rather desire more innovative partners than more guidelines.

Long term studies over many years was the desire of an owner. His focus was clearly set on the day to day performance in practice.

Finally the governmental decision maker would like to have more basic information on what is possible and what is available with natural ventilation. He desires like every aforementioned group collections of well documented examples of realised buildings and overviews of available products on the market and their integration.

**Desirable new components**

The desired new components for natural ventilation mentioned by the interviewees depends on their proficiency.

The following desires were raised by the architect's group:

- Multifunctional human skin like systems for façades. Materials like Gore Tex, allowing for a controlled air exchange with the outside in a new manner.
- Inlets with better design: visual, air flow and draught performance. Better control systems for natural ventilation.
- Components that are explicitly designed for an energy efficient operation in natural ventilation systems with low pressure differences. Self regulatory systems with automatic adaptation to the indoor and outdoor conditions.
- Slide windows and windows with equal profile depths over screen and frame.

The consulting engineers desires were more on the technical side. Simple, low profile components for mechanical ventilation that can be used also in hybrid natural-mechanical systems were mentioned as well as wind and rain protected ventilation windows and air inlets with a somehow controllable airflow rate.

One of the contractor underlined the market demand for a new product, they develop currently in house: Automated lockable windows with the motor invisibly integrated into the window frame so that security, building tightness and aesthetics requirements can be met.

The developers desires are

- Smart façade systems.
- Heat recovery systems for natural ventilation.
- Control systems for large and complex buildings.

One of the owner focused on the building as a whole and desires complete integrated solutions and systems. The governmental decision maker argued that before the desired products can be identified, the technically possible concepts of advanced natural ventilation have to be known and the bottlenecks in application have to be identified. To eliminate these bottlenecks, he wishes the development of better components.

## *Specific building project*

13 of the 15 interviewees also filled in the questionnaire on a specific building project with the exceptions of one architect and the governmental decision maker.

The results in the figures in this section of the report are the average of all the buildings included in the interviews.

**The buildings**

All the buildings are office buildings. One of the building is a new exhibition hall with a large office complex attached on. Nine of the thirteen office buildings are new. They have been built within the last five years or are currently under construction. Three buildings have recently been refurbished and one building is an elder building from the fifties.

All of the buildings are located in an urban or sub-urban area with very strong exposure to traffic in some of the cases at hand.

The buildings have from 3 to 10 storeys and a floor area between 1,000 and 67,000 $m^2$ (total building complex, including exhibition halls). Most of them have 4 to 6 storeys and a floor area between 3,000 and 18,000 $m^2$.

**Design**

Approximately half of the buildings have mechanically ventilated offices. In about 70 % of the buildings are also naturally ventilated offices present. Some 20 % of the buildings have both mechanically and naturally ventilated offices, explaining the total exceeding 100%. All the canteens and most of the meeting rooms in the buildings have mechanical ventilation. Heat recovery is included in all the mechanical ventilation plants. All the buildings but one have mechanical exhaust from the lavatories or full mechanical ventilation in the lavatories. Regarding typical ventilation systems in office buildings refer to annex I.

Most of the natural ventilated offices have an ordinary system with ordinary windows. Some of the buildings have an atria or another type of open vertical connection between the stories. Half of the buildings have roof openings, usually in the community areas and several of these are only supposed to be opened in case of fire.

Most of the offices have external solar shading. The rest of the them have either protective glazing, internal solar shading or solar shading between the two panes of the window.

The heavy structure is in more than 50 % accessible to the air. About one third of the offices have a high ceiling. In another third of the buildings, the rooms are furnished with false ceilings.

**Critical parameters**

The interviewees perception of the critical parameters for the design of the ventilation system in the offices is shown in figure 12. Each interviewee were allowed to point out maximum 5 critical parameters and were ask to prioritise them from 1: *Low* to 5: *High.*

However, some interviewees have criticised the applied system of prioritisation because it forced them to artificially compare different qualities like i.e. fire regulations with winter draught. Therefore the graph below shouldn't be read as an exact ranking but as a collection of relevant factors for the design.

According to the Swiss interviewees, the construction costs made the biggest impact on the design followed by the summer room temperature and the indoor air quality. External noise, winter room temperature and operating costs came next followed by external pollution, individual controllability and solar loads. Surprisingly neither security issues nor fire regulations have according to the interviewees a big influence on the design, although they were mentioned by the architects to be quite stringent.

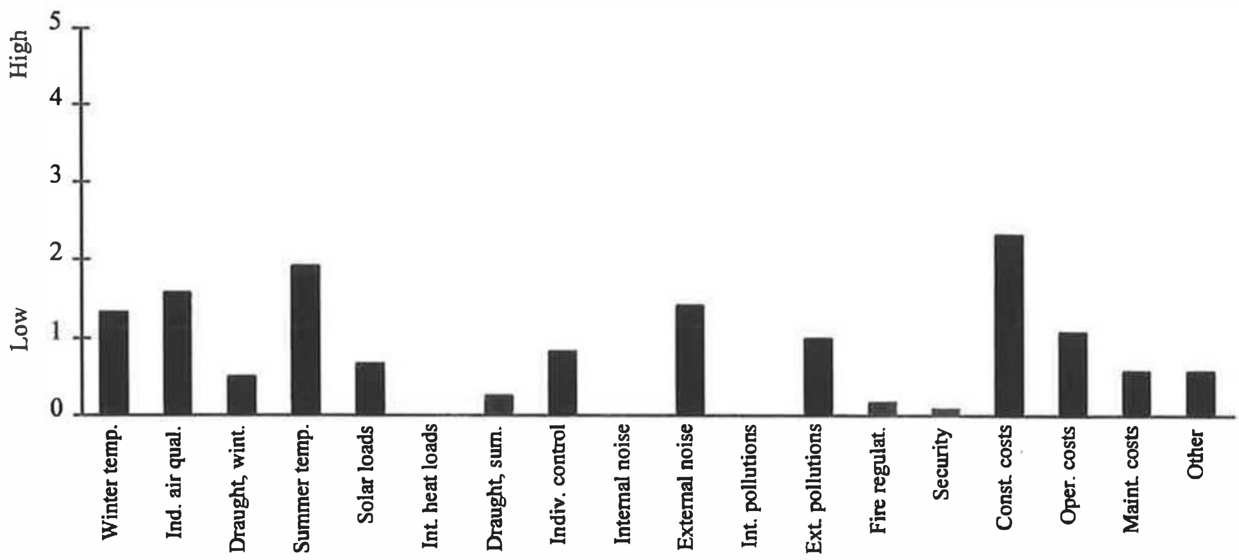


*Figure 12. Critical parameters in the design of the buildings.*

**Influence**

The interviewees perception of the persons or conditions having the biggest influence on the chosen design is shown in figure 13. Again each interviewee were allowed to point out a maximum of 5 influence groups and factors and were ask to prioritise them from 1: *Low* to 5: *High.*

The architects followed by the owners and the consulting engineers are the ones with the highest influence on the chosen design. The architect is indicated by nearly half of the interviewees as the person with the highest influence. All the architects believe that the architects have the biggest influence. The owner, sometimes also the investor, the developer and the user were also mentioned quite often as the person with the biggest influence. Depending on the background of the interviewee he favoured one or the other of the above group. In general always the person with the money was meant, which is not necessarily always the same person. Both the consulting engineer and the building site were indicated once as the person/factor with the highest influence.

The reading in the 'other' column originates from an architect. He said that for public buildings it is the competition jury that has also a very big influence. Again the jury can be understood as a representative of the institution responsible for the finances of the building construction project.

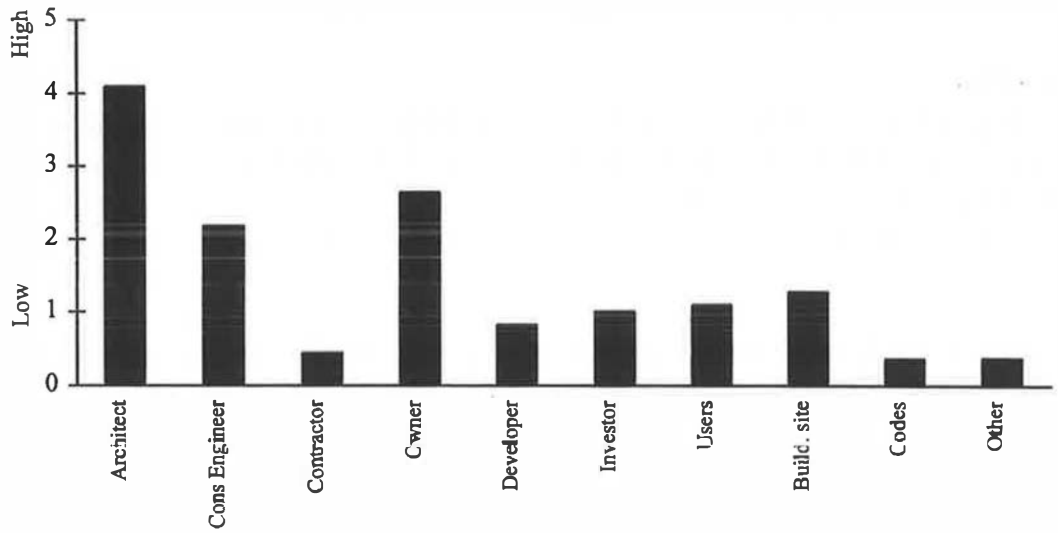


*Figure 13. Influence on the design of the buildings.*

# Summary and conclusions

The objective of the study is to identify barriers restricting the implementation of natural or simple fan assisted ventilation systems in the design of new office type buildings and in the refurbishment of existing such buildings. The perceived barriers are identified in an in-depth study with structured interviews based on questionnaires among leading designers and decision makers. The interviews have focused on general knowledge, viewpoints, experience and perceived problems with natural ventilation in office type buildings and on the decisions actually taken in specific building projects. The interviews were performed among: 5 architects, 3 consulting engineers, 2 contractors, 2 developers, 2 owners and a governmental decision maker.

## *Conclusions*

The interviews identify a significant lack of knowledge and experience on special designed natural ventilation in office buildings compared to the knowledge and experience on mechanical ventilation. In addition there is a lack of sources to natural ventilation knowledge in standards, guidelines and building studies and a desire for new design tools on natural ventilation including also calculation rules and easy to use, simple and advanced computer programmes.

The knowledge and experience on ordinary natural ventilation in offices is on the same level as on mechanical ventilation. Only a few of the interviewees are not dealing with ordinary naturaly ventilated office buildings. But in case of ordinary natural ventilation windows are often just placed by lighting and aesthetic considerations, but not by ventilation considerations.

There is a need for well documented examples of buildings with special designed natural ventilation. There is a lack of knowledge in terms of the integration with other components but also of the performance of the system. Heat recovery should possibly be included in the system for achieving energy efficiency in the whole year round performance. Also smart control systems should be available to run the system user independent. In addition there is a moderate need for new components like windows with better air flow and draught performance, better controllability and better design.

In the interviewees' perception mechanical ventilation has several advantages compared to natural ventilation regarding cooling effectiveness, ability to remove odours and pollutants, ability to prevent ingress of odours and pollutants, insulation against external noise and central controllability, especially if the mechanical ventilation systems are well designed. Nevertheless the interviewees do not expect a higher user satisfaction in mechanical ventilated offices. In fact they expect the highest user satisfaction in natural ventilated cellular offices, where also the highest individual controllability is expected.

All interviewees expect lower installation, lower running and lower maintenance costs for natural office ventilation in than for mechanical ventilation.

Construction costs are the most critical design parameter, followed by summer room temperatures, indoor air quality external noise and winter room temperature. From the people involved in the design process, the architects followed by the owners and consulting engineers have the biggest influence on the design of a building.

Fee structures for design, liability to natural ventilation design in relation to lack of calculation rules, standards and guidelines and the fact that the design of mechanical ventilation systems to day are the basis for the existence of the HVAC consulting engineers causes problems to the application of natural ventilation in office buildings.

Restrictions to the use of natural ventilation in office buildings from building regulations, codes, norms and standards are limited, but problems can be cause by fire regulations and by the guidelines in the Building Regulations about the need for mechanical ventilation in meeting rooms and canteens.

On average the interviewees expect a slightly increased future use of natural ventilation in office buildings in Switzerland. In general the architects have the highest expectation of increasing use of natural ventilation. The main reasons for expecting increasing use of natural ventilation are the saving of resources, the lower costs, the green building trend and the general preference of architects for natural ventilation. The main reason for expecting a decreasing use of natural ventilation is the difficulty of integration of heat recovery in natural ventilation system and the doubted energy efficiency of natural systems without heat recovery. Also some areas were identified, were natural ventilation is not suitable like rooms with high heat loads (> $30 W/m^2$).

## *Recommendations*

It is necessary with further improvement of natural ventilation system concepts, components, controls and design tools to encourage the wider uptake of natural ventilation in office buildings and to accelerate natural ventilation as a main design option in new and refurbished office buildings where good natural ventilation is sufficient to obtain comfortable indoor climate and good air quality with high user satisfaction and low energy consumption, installation and maintenance costs.

Simple, energy efficient, low cost natural ventilation system concepts for new and refurbished office buildings have to be developed and tested so that the use of natural ventilation in the majority of ordinary office buildings are not a technical and architectural challenge but a simple and well approved design solution.

Standards and guidelines have to be improved to be a better technical and legal background for the design of natural ventilated office buildings. The standards and guidelines should also include general accepted, simple and easy to use calculation rules for the design of natural ventilation.

Simple design tools: easy to use computer programmes or diagrams that can be used in the early design process by architects, consulting engineers or design teams to analyse the advantages and disadvantages of different ventilation concepts have to be developed.

The development of specially for natural ventilation designed components and control systems for natural ventilation has to be improved to allow for a wider range of application.

The general knowledge on natural ventilation among practitioners has to be improved. Among architects, consulting engineers and possibly also contractors the improved knowledge must come from basic and post graduate education programmes, source books and building studies. Among developers and owners the improved knowledge must be supplied by simple, easy to understand descriptions and examples.

It may also be necessary to adjust the fee structure for the design of office buildings to pay the designers for the energy, indoor climate and total cost advantages of there design solutions and not for the amount of equipment installed in the building.

# *NatVent*™

*Overcoming technical barriers to low-energy natural ventilation in office type buildings in moderate and cold climates*

EC CONTRACT: JOR3-CT95-0022 (DGXII)
BBW No. 95.0144

# Barriers to Natural Ventilation Design of Office Buildings

## Annexes to National Report: *Switzerland*

SULZER INFRA

**Sulzer Infra Lab AG**

*Dr. René Cotting*

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# Contents

# Annex I: Typical ventilation systems in office buildings

The objective of this annex is to give foreigners some background knowledge on typical ventilation systems in Swiss office buildings and on the Swiss tradition on office ventilation. The description is based on the authors immediate knowledge and must be considered as such and not as a scientific or statistic work.

Approximately half of all new constructed office buildings are with natural ventilation of the offices. The other half are with mechanical ventilation of the offices. The tradition for using mechanical ventilation in offices dates back to the 60's. Before that nearly all office buildings where naturally ventilated.

**Natural ventilation**

New naturally ventilated office buildings are often designed with simple single sided ventilation of the office area by window airing. Ventilation vents are only rarely used. Swiss office buildings are normally relatively air tight, so the additional external air exchange through leakage's in the building envelope is limited. New common natural designs are preferred in unproblematic sites, where window opening is possible and the total loads are < 30 W/m$^2$.

The offices are often cellular offices for one or a few persons. Large open plan offices can be found as well. Natural ventilation of offices for several persons is sometimes seen but natural ventilation of open plan offices is seldom.

In new office buildings with naturally ventilated offices the canteen, assembly halls and meeting rooms are normally mechanically ventilated. There is usually also mechanical exhaust from the lavatories.

Naturally ventilated buildings build before approx. 1960 and used for offices are normally without vents, without mechanical ventilation of canteen, assembly halls and meeting rooms and with stack ducts from lavatories. In case of refurbishment the windows are often replaced and mechanical ventilation is installed in the canteen and sometimes also in assembly halls and meeting rooms. Usually also mechanical exhaust from lavatories is installed during refurbishment of a building. Sometimes a refurbishment also includes the installation of mechanical ventilation in the offices.

**Mechanical ventilation**

New and refurbished mechanically ventilated office buildings are nearly always with heat recovery and without return air to the offices. The typical external air exchange rate in the offices are 1.5-3 ach, suggested are 30 m$^3$/h per person (non smoker). Room heating is normally supplied separately by radiators with thermostatic valves under the windows. There is no tradition for active mechanical cooling of the supply air in Swiss office buildings. Only in rooms with high loads (trader rooms in banks with lots of computer power installed) mechanical cooling is usually adopted. However, this installation requires special permission from the local building authorities. Also humidifying of the supply air is seldom. The possibility for additional airing through the windows at summer is now often foreseen.

In recent years mechanical ventilation systems with VAV (Variable Air Volume) and individual room control of the supply air flow according to excess room temperature have become more common.

In older mechanical ventilated office buildings build in the 60's and in the 70's before the first energy crisis the ventilation plants are normally constructed without heat recovery, commonly as a dual system and often with high external air exchange rates. The energy consumption of these systems is very high and many of them have therefore been improved or replaced by more energy efficient mechanical ventilation systems.

# Annex II: Requirements in codes related to natural ventilation

This annex gives an overview of requirements in Swiss building regulations, occupational health regulations, standards, codes etc. related to natural ventilation systems or simple fan assisted ventilation systems in office buildings. The objective is to identify requirements possible restricting the implementation of natural ventilation systems or simple fan assisted ventilation systems in office building. Requirements related to mechanical ventilation in office building are included in the overview if they can also be used on natural ventilation systems or simple fan assisted ventilation systems. From a legal point of view all ventilation systems including a fan e.g. also simple fan assisted ventilation systems would possible be considered to be mechanical ventilation systems and must fulfil the requirements to mechanical ventilation systems.
Due to the foederalistic structure of Switzerland, as many regulations as communities exist. Therefore a general overview is impossible to give and we renounce ourselves here to the Kanton Zürich, without going down to community level.

**Relevant documents**

*Applicable for whole Switzerland:*

**SIA 102:** *Reglementations for fees and services for Architects. Swiss Counsel of Architects and Engineers (SIA). 1984 (in German and in French)*
The norm describes the rights and duties of both partners in contracts with an architect. Also the basis for the calculation of the architect's fee is given (and updated every year).

**SIA 103:** *Reglementations for fees and services for Civil Engineers. Swiss Counsel of Architects and Engineers (SIA). 1984 (in German and in French)*
The norm describes the rights and duties of both partners in contracts with a civil engineer. Also the basis for the calculation of the civil engineer 's fee is given (and updated every year).

**SIA 108:** *Reglementations for fees and services for Machine and Electrical Engineers. Swiss Counsel of Architects and Engineers (SIA). 1984 (in German and in French)*
The norm describes the rights and duties of both partners in contracts with a machine or electrical engineer. Also the basis for the calculation of the engineer 's fee is given (and updated every year).

**SIA 180:** *Heat protection in building construction. Swiss Counsel of Architects and Engineers (SIA). May 1988 (in German and in French)*
The norm describes the requirements for thermal comfort and hygienic conditions. Avoidance of building damages in energy saving operation. The energy consumptiomn of heating, ventilation and cooling is not subject of this norm.

**SIA 180/3:** *Annual heat consumption of buildings. Swiss Counsel of Architects and Engineers (SIA). May 1988 (in German and in French)*
The norm describes a simple procedure to assess the annual energy consumption of a building including transmission, losses induced by ventilation and heating of consumable water.

**SIA 181:** *Noise protection in building construction. Swiss Counsel of Architects and Engineers (SIA). April 1988 (in German and in French)*
The norm describes a simple procedure to assess the annual energy consumption of a building including transmission, losses induced by ventilation and heating of consumable water.

**SIA 382/1:** *HVAC installations - technical requirements. Swiss Counsel of Architects and Engineers (SIA). April 1989 (in German)*
Details the technical requirements for HVAC installations like ventilation rates for different room categories.

| | | |
|---|---|---|
| | | *Escape pathways shall not be used for air guidance. For staircases separate HVAC systems shall be foreseen. The ventilation of corridors has to occur separately from the other HVAC systems and storey wise.'* |
| Noise | **SIA 181** | External noise protection:<br>As a measure for external noise protection, the standard noise level difference $D_{n,T,w}$ following ISO 717/1 recorded on site with closed windows is applicable. |
| Energy | **BBV 1** | *'Exceeds either the foreseen cooling power or the heating power for humidification 20 kW it has to be shown in the planning permission that a air conditioning system is necessary.'* |
| | **SIA 382/1** | *'With the aim of saving energy several Cantons and Communities demand an evidence for the necessity of a ventilation or a HVAC system, especially for air cooling and air humidification.'*<br><br>The energy consumption should be kept low by considering the following means:<br>- External solar protection<br>- Direct ventilation of high internal loads<br>- If possible usage of free cooling<br>- Only lighting if really necessary<br>- Heat recovery and usage of waste heat of machines etc.<br>- Adaptation of the ventilation rate to the actual demand (CO2 sensors)<br>- Low pressure drop designs<br>- Individual room regulation at least in large systems |
| | **EEF** | *'If a glazed annex to the building is furnished with a heating system designed for temperatures above 10 °C, the annex is regarded as a heated room and has to fullfill the thermal insulation against outdoor air regulation. The glazed annex contributes than also to the used net surface of the building.'* |
| Solar protection | **EEF** | *'The total energy transmission factor of glazed surfaces (g-value) of new buildings and refurbishments shall be lower than 0.15. An external solar protection can is not compulsory on those areas of the façade that are during the observation period in the shade.'* |
| Fee structure | **SIA 102, 103 and 108** | Generally accepted basis for the fee calculation. With annually updated tables. |

# Annex III: Questionnaire on general view

## General view on natural ventilation in office buildings

NatVent - Work Package 1 - Identifying perceived barriers

Questionnaire for structured interview among leading designers and decision makers: architects, consultant engineers, developers, owners, contractors and governmental decision makers responsible of regulations and standards.

### 1. Interviewee

Organisation: ____________________

Address: ____________________

____________________

Telephone: ____________

Fax: ____________

Persons interviewed: ____________________

____________________

### 2. Organisation

Type:
- architects ☐
- consultants ☐
- owners ☐
- builders ☐
- other: ____________ ☐

Disciplines:
- architects ☐
- engineers ☐
- lawyers ☐
- economists ☐
- other: ____________ ☐

Typical building types designed/owned:
- offices ☐
- schools ☐
- institutions ☐
- housing ☐
- production ☐
- other: ____________ ☐

Number of employees: ____________

Interviewer: ____________ Organisation: ____________

## 3. Knowledge

(*check one box in each line*)

| | None | → | → | → | Thorough |
|---|---|---|---|---|---|
| Knowledge on mechanical ventilation in offices | ☐ | ☐ | ☐ | ☐ | ☐ |
| Knowledge on heat recovery | ☐ | ☐ | ☐ | ☐ | ☐ |
| Knowledge on mechanical cooling | ☐ | ☐ | ☐ | ☐ | ☐ |
| Knowledge on ordinary natural ventilation in offices (*ordinary windows, ordinary vents*) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Knowledge on special designed natural ventilation (*special ventilation windows, advanced vents, internal (ventilation) openings, roof openings etc.*) | ☐ | ☐ | ☐ | ☐ | ☐ |

Remarks:__________________________________________________

__________________________________________________________

## 4. Experience

Designed/owned new office buildings (*number, $m^2$-floor area, per year*): ____________

Per cent of new buildings:

Mechanical ventilation in the offices: __________

Ordinary natural ventilation in the offices (*ordinary windows, ordinary vents*): __________

Specially designed natural ventilation in the offices: __________
(*special ventilation windows, advanced vents, internal (ventilation) openings, roof openings etc.*)

Designed/owned refurbished office (*number, $m^2$-floor area, per year*): ____________

Per cent of refurbished buildings:

Mechanical ventilation in the offices: __________

Ordinary natural ventilation in the offices (*ordinary windows, ordinary vents*): __________

Specially designed natural ventilation in the offices: __________
(*special ventilation windows, advanced vents, internal (ventilation) openings, roof openings etc.*)

Remarks:__________________________________________________

__________________________________________________________

## 5. Project fee

Per cent of projects:

Fixed fee: __________

Percentage of construction costs: __________

Per hour: __________

Other:____________________________________ __________

Remarks:__________________________________________________

__________________________________________________________

## 6. **<u>Natural</u> ventilation in <u>cellular</u> offices**

General view on perceived advantages / problems

| *Design* (*check one box in each line*) | Poor | → | → | → Excellent | |
|---|---|---|---|---|---|
| Ease of design | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of design guidelines and advice | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of products | ☐ | ☐ | ☐ | ☐ | ☐ |
| Flexibility to building use | ☐ | ☐ | ☐ | ☐ | ☐ |
| User satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Performance in practice* | Poor | → | → | → Excellent | |
|---|---|---|---|---|---|
| Cooling effectiveness | ☐ | ☐ | ☐ | ☐ | ☐ |
| Draught minimisation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to remove odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to prevent ingress of odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Insulation against external noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Generation or transmission of internal noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Control* | Poor | → | → | → Excellent | |
|---|---|---|---|---|---|
| Central controllability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Local controllability (per office) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Individual controllability (per person) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Cost* | Inexpensive→ | | → | →Expensive | |
|---|---|---|---|---|---|
| Installation costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Running costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Maintenance costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Other:*____________________ | ______ | | → | ______ | |
|---|---|---|---|---|---|
| ____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| ____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

*Remarks:*________________________________________

________________________________________________

## 7. **Mechanical** ventilation in **cellular** offices

General view on perceived advantages / problems

| *Design* (*check one box in each line*) | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Ease of design | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of design guidelines and advice | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of products | ☐ | ☐ | ☐ | ☐ | ☐ |
| Flexibility to building use | ☐ | ☐ | ☐ | ☐ | ☐ |
| User satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Performance in practice* | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Cooling effectiveness | ☐ | ☐ | ☐ | ☐ | ☐ |
| Draught minimisation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to remove odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to prevent ingress of odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Insulation against external noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Generation or transmission of internal noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Control* | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Central controllability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Local controllability (per office) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Individual controllability (per person) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Cost* | Inexpensive→ | | → | | →Expensive |
|---|---|---|---|---|---|
| Installation costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Running costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Maintenance costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Other*:____________________ | ______ | | → | | ______ |
|---|---|---|---|---|---|
| ____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| ____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

*Remarks*:________________________________________

________________________________________________

## 8. <u>Natural</u> ventilation in <u>open plan</u> offices

General view on perceived advantages / problems

| *Design* (*check one box in each line*) | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Ease of design | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of design guidelines and advice | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of products | ☐ | ☐ | ☐ | ☐ | ☐ |
| Flexibility to building use | ☐ | ☐ | ☐ | ☐ | ☐ |
| User satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Performance in practice* | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Cooling effectiveness | ☐ | ☐ | ☐ | ☐ | ☐ |
| Draught minimisation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to remove odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to prevent ingress of odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Insulation against external noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Generation or transmission of internal noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Control* | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Central controllability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Local controllability (per office) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Individual controllability (per person) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Cost* | Inexpensive→ | | → | | →Expensive |
|---|---|---|---|---|---|
| Installation costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Running costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Maintenance costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other:____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Other*:____________________ | ______ | | → | | ______ |
|---|---|---|---|---|---|
| ____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| ____________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

*Remarks*:________________________________________

________________________________________________

## 9. **Mechanical** ventilation in **open plan** offices General view on perceived advantages / problems

| *Design* (*check one box in each line*) | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Ease of design | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of design guidelines and advice | ☐ | ☐ | ☐ | ☐ | ☐ |
| Availability of products | ☐ | ☐ | ☐ | ☐ | ☐ |
| Flexibility to building use | ☐ | ☐ | ☐ | ☐ | ☐ |
| User satisfaction | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: ________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Performance in practice* | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Cooling effectiveness | ☐ | ☐ | ☐ | ☐ | ☐ |
| Draught minimisation | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to remove odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ability to prevent ingress of odours and pollutants | ☐ | ☐ | ☐ | ☐ | ☐ |
| Insulation against external noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Generation or transmission of internal noise | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: ________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Control* | Poor | → | → | → | Excellent |
|---|---|---|---|---|---|
| Central controllability | ☐ | ☐ | ☐ | ☐ | ☐ |
| Local controllability (per office) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Individual controllability (per person) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: ________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Cost* | Inexpensive→ | | → | | →Expensive |
|---|---|---|---|---|---|
| Installation costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Running costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Maintenance costs | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: ________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

| *Other*: ________________ | ________ | | → | | ________ |
|---|---|---|---|---|---|
| ________________ | ☐ | ☐ | ☐ | ☐ | ☐ |
| ________________ | ☐ | ☐ | ☐ | ☐ | ☐ |

*Remarks*: ________________________________________

________________________________________

## 10. Your source to natural ventilation knowledge

Title, organisation etc.:

Standards

Guidelines

Building studies

Experience

Own design

Other:

## 11. Expected future use of natural ventilation in office buildings

Decreasing→Unchanged→Increasing

Future use

Why:

## 12. Requirements in building codes, norms, standards, working condition codes etc. restricting the use of natural ventilation in offices

None → → Comprehensive

Restrictions

Which:

## 13. Desirable new design tools for natural ventilation

(*source books, guide lines, examples, simple/advanced computer programmes etc.*)

## 14. Desirable new components for natural ventilation

(*air inlets, control systems etc.*)

# Annex IV: Questionnaire on specific building project

## Specific building project

NATVENT - Work Package 1 - Identifying perceived barriers

Questionnaire for structured interview among leading designers and decision makers: architects, consultant engineers, developers, owners and contractors.

### 1. Interviewee

Organisation: ____________________

Address: ____________________

____________________

Telephone: ____________________

Fax: ____________________

Persons interviewed: ____________________

____________________

### 2. Building

Name: ____________________

Address: ____________________

____________________

Type (*offices, education, laboratory, light industry etc. -or combinations*):

____________________

Constructed (*year*): ____________________

Refurbished (*year*): ____________________

Site (*urban, sub-urban, industrial, rural*): ____________________

$m^2$-floor area: ____________________

Number of stories: ____________________

Depth (*distance from facade to facade*): ____________________

Storey height: ____________________

Interviewer: ____________________ Organisation: ____________________

## 3. The design

| | | Offices | Meeting rooms | Canteen | Corridors | Stairways | Entrance hall | Atria | Lavatories | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Room types: | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| Ventilation system: | Mechanical ventilation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Mechanical exhaust | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Natural ventilation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Heat recovery | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Night time ventilation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mechanical cooling: | In ventilation system | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Cooled ceilings | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| External openings: | Ordinary windows | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Special ventilation windows | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Ordinary vents | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Advanced vents | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Stack ducts (small cross-sec.) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Ventilation chimney (large c.-s.) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Roof openings (skylights) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Ducted air supply | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Int. horizontal air flow: | Doors | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Ventilation openings | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Open connection | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Int. vertical air flow: | Ventilation openings | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Open connection | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Solar shading: | Internal | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Between panes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | External | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Protective glazing | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ceilings: | High ceiling (> 2.7 m) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | False ceiling | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Exposed heavy structure | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Floor and walls: | Exposed heavy floor | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Exposed heavy internal walls | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Exposed heavy external walls | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: | ______________ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | ______________ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Remarks:______________________________________________

______________________________________________________

## 4. Background for the design

| | | Offices | Meeting rooms | Canteen | Corridors | Stairways | Entrance hall | Atria | Lavatories | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Room types: | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| Critical parameters: | Room temperatures, winter | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| (*max. 5 critical para-* | Indoor air quality | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| *meters per room type,* | Draught, winter | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| *prioritise from:* | Room temperatures, summer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| *1. 'low' to 5. 'high'*) | Solar loads | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Internal heat loads | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Draught, summer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Individual control | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Internal noise | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | External noise | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Internal air pollution/odours | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | External air pollution/odours | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Fire regulations | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Security | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Construction costs | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Operating costs | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | Maintenance costs | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: | ________________ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | ________________ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Remarks:______________________________________________

______________________________________________________

## 5. Biggest influence on chosen design

(*max. 5 checks, prioritise from: 1. 'low' to 5. 'high'*)

- Architect ☐
- Consultant engineer ☐
- Contractor ☐
- Owner ☐
- Developer ☐
- Investor ☐
- Users ☐
- The building site ☐
- Requirements in building codes, norms, standards etc. ☐
- Other:______________________________ ☐

Remarks:______________________________________________

______________________________________________________

# Annex V: Interviewees opinions, remarks and comments

A: Architect
E: Consultant engineer
C: Contractor
D: Developer
O: Owner
G: Governmental decision maker

**Questionnaire for structured interview among leading designers and decision makers**

*1. Interviewee*

*2. Organisation*

O1: The company has its own maintenance and service division.
O2: The company has its own maintenance and service division.

*3. Knowledge*

A2: Knowledge on ventilation, both mechanical and natural, from in depth discussions with the consulting engineer on several projects. Stressing the importance of well functioning teams.
A3: Knowledge from presented examples in international magazines. There is not much available in Switzerland itself.
A5: HVAC Solutions greatly influenced by the engineer.
D2: Focus mainly on investments and income from rent. Costs of a working place shall not exceed CHF 100,000.- to achieve a market rent. Satisfying indoor climate: temperature and indoor air quality are key issues.
O1: Engineer by training who is working in the maintenance department. Practical experience.
O2: He is not a technician but focuses on administration and economics of the buildings.
G: Has seen many examples in practise. Experience and analytical skills to evaluate the overall energy consumption as the most important quantity.

*4. Experience*

E1: Own designs identified as best source of experience.
E2: Difficult to modify the basic ventilation concept during a refurbishment of a building. Innovative but well adapted and thought through concepts are required.
E3: Much experienced gained from post construction accompanying the building for energy optimisation together with the building facility manager. It helped also to get aware of the problems showing up in daily use.
C1: Not much experience yet. They have identified natural ventilation as the selling argument for their components, i.e. electrified windows. However a thorough knowledge on natural ventilation is required to set up a properly working control system. They see ***NatVent™*** as a chance to fill this gap.
C2: Focus of experience in the mechanical regime.

*5. Project fee*

A3: Fixed fee and per hour payment only for consulting jobs.

A4: Payment is always based on the regulations of the Swiss Counsel of Architects and Engineers (SIA).
O1: Management fees.
O2 New fee model: Starting from a fixed fee for the architect based on the initial budget for the predicted construction costs, the architect's fee is increased proportionally to the amount the real construction costs remain under the predicted construction costs. The architect participates in this model directly on the owner's savings. The quality level of the execution is defined in advanced and supervised by an independent quality control. With this fee structure relationship between the architect's fee and the construction cost is reversed.

*6. Natural ventilation in cellular offices*
A3: For cellular offices in general a central controllability is not desired. The advantage of cellular offices lies in the local controllability.
A4: It may be not be the availability of the products itself but the knowledge about their existence and examples how they are successfully integrated into a whole system.
E1: Influence of the thermal mass on the cooling effectiveness
C2: Assumed was a building with normal loads, sun shading devices and using stack effect for ventilation.
D2: The perception is specific to the area of Zug in Switzerland, where most of the company's activities are.
O2: The building service and management department of this insurance company is lead by a person specialised in management and administration. Technical issues are not within the main focus. He mentioned to be in charge of some naturally ventilated buildings with overheating problems.

*7. Mechanical ventilation in cellular offices*
E3: Mechanical ventilation allows generally for higher heat loads than natural ventilation without exceeding comfort criteria.

*8. Natural ventilation in open plan offices*
A3: The user satisfaction depends highly on the implementation of the natural ventilation concept.
A5: No personal experience with natural ventilation in open plan offices.

*9. Mechanical ventilation in open plan offices*
---

*10. Your source to natural ventilation knowledge*
A1: Other sources: traditional architecture from the period when energy was not so easily available.
A3: Other sources: own studies, international architectural periodicals.
A4: Other sources: books, international periodicals and intuition.
E1: Other sources: books, periodicals, publications
E2: Other sources: physics, thermo- and aerodynamics
C1: Other sources: seminars and publications
C2: Other sources: discussions, seminars and publications
D1: Other sources: symposia and conferences
O1: Other sources: published studies about engineering and energy technology
O2: Other sources: in-house architect, national periodicals

*11. Expected future use of natural ventilation in office buildings*
A1: Increase only in Europe; people are sensitised strongest for energy savings here.
A2: Costs and environmental awareness are the motors towards natural ventilation.
A3: Increased usage of natural ventilation because of the energy efficiency, the comfort levels and the overall costs (investment and running costs).
A4: The costs, perceived comfort criteria and the trend back to nature support natural ventilation.

A5: Ecology and costs

E1: Most of the buildings are already built - most of the old ones without mechanical ventilation - and a building's structure can later not be changed easily.

E2: Energy efficiency is the key factor. Heat recovery becomes advisory for buildings in our climate. Therefore mechanical ventilation is more favourable, but the possibility for manual window opening should be foreseen

E3: The low costs and new technical developments support the use of innovative natural ventilation concepts.

D1: More pioneering research is required to bring natural ventilation any further.

D2: Not much office buildings will be constructed in the next future in Switzerland. There is an overcapacity on the market.

O1: Investment costs, flexibility in usage as well as environmental awareness will lead to an increased usage of natural ventilation.

O2: Energy efficiency of natural ventilation is good. Mechanical ventilation should be chosen, when natural forces become insufficient (high loads).

G: Better performance of mechanical systems in terms of comfort and energy efficiency (heat recovery).

*12. Requirements in building codes, norms, standards, working conditions codes etc. restricting the use of natural ventilation in offices*

A1: Fire regulations

A2: Working environment code: Windows of office buildings have to face the outside.

A3: Fire regulations; all the standards have been designed in view of mechanical ventilation. The way is regulated instead of specifying apropriate target values.

A4: Technical restrictions, laws

A5: In restaurants mechanical ventilation is compulsory.

E1: From a certain ventilation level on, measured by its energy consumption, heat recovery becomes compulsory.

E3: Guidelines should be target, but not parameter oriented.

D2: Requirements in the standards are designed to meet also extreme cases and are too high for typical applications.

*13. Desirable new design tools for natural ventilation*

A1: Better guidelines, books with realised examples

A2: Simple computer tools, books with realised examples, tutorial books

A3: Simple and more refined computer programmes. Broader choice of building materials (i.e. for façades)

A4: On-line easy-to-use documentation and databases on the internet covering also realised examples with performance evaluation.

A5: Basic information and planning tools; well documented examples

E1: Market screening on the availability of products and systems, simple computer tools and well documented examples.

E2: Combined tools: energetic and perceptive (draughts, smells, noises, temporal variances) optimisation of HVAC systems

E3: Design guide lines, experience with the usage of components on the market, guidelines how to design naturally ventilated open plan offices.

C1: Well documented examples

C2: Well documented examples

D1: Well documented examples

D2: Innovative partners

O1: Well documented examples with long term studies over many years. Simple and advanced computer programmes.

G: Well documented examples of realised buildings. Market screening of available products.

*14. Desirable new components for natural ventilation*

A1: Intelligent well designed air inlets including heat recovery e.g. solar walls. Double facades.

A2: Inlets with better design: visual, air flow and draught performance. Better control systems for natural ventilation. Guidelines on how to use the components and design the system.

A3: Better vents and windows and better automatic control of windows.

A4: None. The iunterviewee has designed himself a window for natural ventilation.

A5: If the design with natural ventilation was more common, the components will come by themselves.

E1: The components exist, but how to use them is the problem.

E2: Windows with better controllability, draught performance and air flow.

E3: Heat recovery in natural ventilation.

C1: Integrated system and component solutions.

C2: Smart windows including a hatch, that can be left open by thc occupants upon leaving the office.

D1: Smart control systems and smart facade systems.

D2: No wish of new components. The existing components will normally satisfy the requirements in the Building Regulations, also with respect to external noise.

O1: Natural ventilation as an engineering design task.

O2: So far no natural ventilation concept based on available components can solve the problems of removing the heat from the very high heat loads.

G: Heat recovery solutions for natural ventilation systems.

**Questionnaire for structured interview on specific building project**

*1. Interviewee*

*2. Building*

A2: Same building as E3: the EWZ building is Zurich which is also sdubject to the monitoring programme of NATVENT's WP2.

E3: Same building as A2: the EWZ building is Zurich which is also sdubject to the monitoring programme of NATVENT's WP2

C2: Building for the education departement with mjany class rooms.

*3. The design*

A4: On the south facade on the top floor a special protective glazing was chosen to reduce the solar heat load.

E1: Free cooling; dry earth register

E2: Separate ducts on the outside for each floor are foreseen, they can be used for both, natural and mechanical designs depending on the owners wish.

*4. Background for the design*

A3: The aim was to construct a building without mechanical ventilation in the offices on a difficult site.

O2: At the time, the building was constructed in 1955, there was no need fr mechanical ventilation.

*5. Biggest influence on chosen design*

A2: The competition jury in institutional building projects was ranked with the second highest priority.

A3: User and site issues are handled by the architect.

A5: Owner and developer are the same.

E1: In house architects and consultant engineers.

E2: Owner, developer and investor are the same.

C1: Owner and investor are the same.

D1: Total service contractor (=interviewee) has the biggest influence.
O1: Owner, developer and investor are the same.
O2: Refurbishment project: the facility manager brings a lot of background know how and has therefore a strong indirect influence.

# Annex VI: Detailed statistics from questionnaires

A: Architect
E: Consultant engineer
C: Contractor
D: Developer
O: Owner
G: Governmental decision maker

## Switzerland, Jan. 8. 1997

### 6. Natural ventilation in cellular offices

| 6.1 Design | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All ex G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.1.1 Easy of design | 4 | 5 | 3 | 4 | 2 | 3.6 | 3 | 4 | 2 | 3.0 | 4 | 5 | 4.5 | 5 | 4 | 4.5 | 2 | 5 | 3.5 | 4 | 3.7 | 4.0 | 3.8 |
| 6.1.2 Guidelines and advice | | 4 | 2 | 5 | 2 | 3.3 | 2 | 1 | 2 | 1.7 | 2 | 5 | 3.5 | 5 | 2 | 3.5 | 2 | 4 | 3.0 | 3 | 2.8 | 3.3 | 3.0 |
| 6.1.3 Products | 2 | 4 | 1 | 2 | 2 | 2.2 | 2 | 1 | 2 | 1.7 | 5 | 5 | 5.0 | 5 | 2 | 3.5 | 4 | 5 | 4.5 | 4 | 3.0 | 4.0 | 3.4 |
| 6.1.4 Flexibility | | 3 | 2 | 5 | 4 | 3.5 | 3 | 2 | 2 | 2.3 | | 2 | 2.0 | 3 | 4 | 3.5 | 4 | 5 | 4.5 | 3 | 2.6 | 4.0 | 3.2 |
| 6.1.5 User satisfaction | 4 | 4 | 4 | 5 | 4 | 4.2 | 3 | 4 | 4 | 3.7 | 4 | 3 | 3.5 | 4 | 4 | 4.0 | 3 | 4 | 3.5 | 4 | 3.8 | 3.8 | 3.8 |

| 6.2 Performance in practice | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.2.1 Cooling effectiveness | 4 | 2 | 2 | 4 | 2 | 2.8 | 1 | 2 | 4 | 2.3 | 4 | 2 | 3.0 | 1 | 1 | 1.0 | 2 | 3 | 2.5 | 2 | 2.7 | 1.8 | 2.3 |
| 6.2.2 Draught minimisation | 4 | 4 | 4 | 4 | 2 | 3.6 | 2 | 2 | 4 | 2.7 | 2 | 4 | 3.0 | 2 | 4 | 3.0 | 4 | 2 | 3.0 | 3 | 3.1 | 3.0 | 3.1 |
| 6.2.3 Removal of odours/poll. | 4 | 4 | 4 | 4 | 3 | 3.8 | 2 | 4 | 2 | 2.7 | 4 | 4 | 4.0 | 2 | 4 | 3.0 | 4 | 2 | 3.0 | 4 | 3.5 | 3.0 | 3.3 |
| 6.2.4 Ingress of odours/poll. | 4 | 2 | 2 | 2 | 2 | 2.4 | 2 | 2 | 2 | 2.0 | 4 | 4 | 4.0 | 2 | 2 | 2.0 | 2 | 2 | 2.0 | 3 | 2.8 | 2.0 | 2.5 |
| 6.2.5 External noise | | 3 | 4 | 2 | 1 | 2.5 | 2 | 2 | 2 | 2.0 | 3 | 4 | 3.5 | 5 | 3 | 4.0 | 2 | 2 | 2.0 | 2 | 2.7 | 3.0 | 2.8 |
| 6.2.6 Internal noise | | 4 | 2 | 4 | 4 | 3.5 | 3 | 4 | 4 | 3.7 | 4 | 4 | 4.0 | 4 | 4 | 4.0 | 4 | 5 | 4.5 | 4 | 3.7 | 4.3 | 3.9 |

| 6.3 Control | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.3.1 Central | | 2 | 2 | 2 | 1 | 1.8 | 2 | 4 | 2 | 2.7 | 5 | 4 | 4.5 | 1 | 2 | 1.5 | 1 | 1 | 1.0 | 1 | 3.0 | 1.3 | 2.3 |
| 6.3.2 Local | | 4 | 5 | 4 | 4 | 4.3 | 3 | 3 | 3 | 3.0 | 4 | 2 | 3.0 | 1 | 4 | 2.5 | 2 | 4 | 3.0 | 4 | 3.4 | 2.8 | 3.2 |
| 6.3.3 Individual | | 4 | 5 | 4 | 4 | 4.3 | 3 | 4 | 4 | 3.7 | 4 | 2 | 3.0 | 3 | 4 | 3.5 | 2 | 4 | 3.0 | 4 | 3.6 | 3.3 | 3.5 |

| 6.4 Cost | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.4.1 Installation | 3 | 2 | 2 | 2 | 2 | 2.2 | 2 | 2 | 2 | 2.0 | 3 | 2 | 2.5 | 1 | 1 | 1.0 | 1 | 2 | 1.5 | 1 | 2.2 | 1.3 | 1.8 |
| 6.4.2 Running | 3 | 2 | 2 | 2 | 1 | 2.0 | 2 | 2 | 2 | 2.0 | 2 | 3 | 2.5 | 1 | 1 | 1.0 | 1 | 2 | 1.5 | 4 | 2.2 | 1.3 | 1.8 |
| 6.4.3 Maintenance | 3 | 2 | 1 | 2 | 2 | 2.0 | 2 | 1 | 2 | 1.7 | 2 | 1 | 1.5 | 1 | 1 | 1.0 | 1 | 1 | 1.0 | 1 | 1.7 | 1.0 | 1.4 |

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## 7. Mechanical ventilation in cellular offices

| 7.1 Design | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.1.1 Easy of design | 4 | 3 | 4 | 4 | 4 | 3.8 | 3 | 4 | 4 | 3.7 | 5 | 3 | 4.0 | 3 | 3 | 3.0 | 3 | 2 | 2.5 | 4 | 3.8 | 2.8 | 3.4 |
| 7.1.2 Guidelines and advice | | 4 | 4 | 5 | 4 | 4.3 | 3 | 4 | 5 | 4.0 | 4 | 5 | 4.5 | 3 | 4 | 3.5 | 4 | 3 | 3.5 | 4 | 4.3 | 3.5 | 4.0 |
| 7.1.3 Products | 3 | 4 | 4 | 5 | 4 | 4.0 | 3 | 5 | 5 | 4.3 | 4 | 5 | 4.5 | 5 | 4 | 4.5 | 4 | 4 | 4.0 | 4 | 4.3 | 4.3 | 4.3 |
| 7.1.4 Flexibility | | 4 | 4 | 4 | 3 | 3.8 | 3 | 4 | 5 | 4.0 | 4 | 4 | 4.0 | 3 | 4 | 3.5 | 3 | 2 | 2.5 | 4 | 3.9 | 3.0 | 3.6 |
| 7.1.5 User satisfaction | 3 | 4 | 2 | 2 | 3 | 2.8 | 4 | 3 | 4 | 3.7 | 3 | 4 | 3.5 | 4 | 3 | 3.5 | 4 | 4 | 4.0 | 3 | 3.3 | 3.8 | 3.5 |

| 7.2 Performance in practice | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.2.1 Cooling effectiveness | 4 | 4 | 4 | 4 | 4 | 4.0 | 4 | 4 | 5 | 4.3 | 4 | 5 | 4.5 | 5 | 4 | 4.5 | 4 | 4 | 4.0 | 5 | 4.3 | 4.3 | 4.3 |
| 7.2.2 Draught minimisation | 3 | 4 | 2 | 1 | 4 | 2.8 | 4 | 4 | 5 | 4.3 | | 4 | | 3 | 2 | 2.5 | 2 | 3 | 2.5 | 3 | 3.6 | 2.5 | 3.0 |
| 7.2.3 Removal of odours/poll. | 4 | 2 | 4 | 4 | 4 | 3.6 | 5 | 4 | 5 | 4.7 | 4 | 4 | 4.0 | 5 | 4 | 4.5 | 4 | 4 | 4.0 | 4 | 4.1 | 4.3 | 4.2 |
| 7.2.4 Ingress of odours/poll. | 4 | 4 | 4 | 4 | 4 | 4.0 | 5 | 4 | 4 | 4.3 | 3 | 4 | 3.5 | 5 | 4 | 4.5 | 5 | 4 | 4.5 | 4 | 3.9 | 4.5 | 4.2 |
| 7.2.5 External noise | | 4 | 4 | 4 | 4 | 4.0 | 5 | 4 | 5 | 4.7 | 3 | 5 | 4.0 | 3 | 4 | 3.5 | 5 | 5 | 5.0 | 4 | 4.2 | 4.3 | 4.2 |
| 7.2.6 Internal noise | | 4 | 3 | 1 | 3 | 2.8 | 4 | 2 | 4 | 3.3 | 4 | 4 | 4.0 | 3 | 3 | 3.0 | 5 | 4 | 4.5 | 4 | 3.4 | 3.8 | 3.5 |

| 7.3 Control | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.3.1 Central | | 4 | 5 | 4 | 4 | 4.3 | 4 | 4 | 5 | 4.3 | 4 | 5 | 4.5 | 5 | 4 | 4.5 | 5 | 4 | 4.5 | 3 | 4.4 | 4.5 | 4.4 |
| 7.3.2 Local | | 4 | 1 | 4 | 3 | 3.0 | 2 | 4 | 4 | 3.3 | 2 | 4 | 3.0 | 5 | 4 | 4.5 | 5 | 4 | 4.5 | 3 | 3.1 | 4.5 | 3.7 |
| 7.3.3 Individual | | 4 | 1 | 4 | 1 | 2.5 | 2 | 4 | 4 | 3.3 | 2 | 4 | 3.0 | 3 | 2 | 2.5 | 5 | 4 | 4.5 | 3 | 2.9 | 3.5 | 3.2 |

| 7.4 Cost | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.4.1 Installation | 3 | 4 | 3 | 4 | 4 | 3.6 | 3 | 4 | 4 | 3.7 | 4 | 5 | 4.5 | 4 | 4 | 4.0 | 4 | 5 | 4.5 | 4 | 3.9 | 4.3 | 4.1 |
| 7.4.2 Running | 3 | 4 | 4 | 4 | 3 | 3.6 | 3 | 3 | 4 | 3.3 | 4 | 4 | 4.0 | 3 | 3 | 3.0 | 4 | 4 | 4.0 | 2 | 3.6 | 3.5 | 3.6 |
| 7.4.3 Maintenance | 3 | 4 | 5 | 4 | | 4.0 | 3 | 4 | 4 | 3.7 | 4 | 3 | 3.5 | 3 | 3 | 3.0 | 4 | 4 | 4.0 | 4 | 3.7 | 3.5 | 3.6 |

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8. Natural ventilation in open plan offices

| 8.1 Design | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.1.1 Easy of design | 4 | 2 | 1 | 2 | 2 | 2.2 | 1 | 1 | 2 | 1.3 | 2 | 1 | 1.5 | 5 | 2 | 3.5 | 2 | | 2.0 | 2 | 1.7 | 2.8 | 2.1 |
| 8.1.2 Guidelines and advice | | 4 | 1 | 2 | 2 | 2.3 | 1 | 1 | 2 | 1.3 | 2 | 1 | 1.5 | 5 | 3 | 4.0 | 4 | | 4.0 | 1 | 1.7 | 4.0 | 2.6 |
| 8.1.3 Products | 2 | 4 | 1 | 2 | 2 | 2.2 | 1 | 1 | 1 | 1.0 | 4 | 1 | 2.5 | 5 | 1 | 3.0 | 4 | | 4.0 | 1 | 1.9 | 3.5 | 2.5 |
| 8.1.4 Flexibility | | 4 | 4 | 4 | 2 | 3.5 | 4 | 2 | 2 | 2.7 | 4 | 2 | 3.0 | 3 | 1 | 2.0 | 4 | | 4.0 | 2 | 3.1 | 3.0 | 3.0 |
| 8.1.5 User satisfaction | 4 | 4 | 4 | 4 | | 4.0 | 2 | 2 | | 2.0 | 4 | | 4.0 | 1 | 2 | 1.5 | 4 | | 4.0 | 2 | 3.3 | 2.8 | 3.1 |

| 8.2 Performance in practice | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.2.1 Cooling effectiveness | 4 | 4 | 3 | 4 | 2 | 3.4 | 2 | 2 | 2 | 2.0 | 4 | 2 | 3.0 | 1 | 2 | 1.5 | 3 | | 3.0 | 2 | 2.8 | 2.3 | 2.6 |
| 8.2.2 Draught minimisation | 4 | 3 | 4 | 4 | 2 | 3.4 | 2 | 1 | 2 | 1.7 | 3 | 2 | 2.5 | 2 | 2 | 2.0 | 4 | | 4.0 | 2 | 2.5 | 3.0 | 2.7 |
| 8.2.3 Removal of odours/poll. | 4 | 1 | 2 | 2 | 4 | 2.6 | 2 | 3 | 2 | 2.3 | 4 | 2 | 3.0 | 2 | 4 | 3.0 | 3 | | 3.0 | 2 | 2.6 | 3.0 | 2.8 |
| 8.2.4 Ingress of odours/poll. | 4 | 2 | 2 | 2 | 2 | 2.4 | 2 | 2 | 1 | 1.7 | 2 | 3 | 2.5 | 2 | 3 | 2.5 | 2 | | 2.0 | 3 | 2.2 | 2.3 | 2.2 |
| 8.2.5 External noise | | 4 | 2 | 4 | 2 | 3.0 | 2 | 2 | 2 | 2.0 | 3 | 4 | 3.5 | 5 | 3 | 4.0 | 3 | | 3.0 | 2 | 2.8 | 3.5 | 3.1 |
| 8.2.6 Internal noise | | 4 | 4 | 4 | 2 | 3.5 | 4 | 4 | 3 | 3.7 | 3 | 5 | 4.0 | 4 | 3 | 3.5 | 4 | | 4.0 | 4 | 3.7 | 3.8 | 3.7 |

| 8.3 Control | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.3.1 Central | | 2 | 2 | 4 | 2 | 2.5 | 2 | 4 | 1 | 2.3 | 4 | 4 | 4.0 | 1 | 1 | 1.0 | 2 | | 2.0 | 1 | 2.9 | 1.5 | 2.4 |
| 8.3.2 Local | | 2 | 4 | 4 | 3 | 3.3 | 3 | 4 | 3 | 3.3 | 4 | 2 | 3.0 | 1 | 1 | 1.0 | 2 | | 2.0 | 4 | 3.2 | 1.5 | 2.5 |
| 8.3.3 Individual | | 1 | 2 | 4 | 1 | 2.0 | 2 | 1 | 2 | 1.7 | 3 | 2 | 2.5 | 1 | 1 | 1.0 | 2 | | 2.0 | 2 | 2.1 | 1.5 | 1.8 |

| 8.4 Cost | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.4.1 Installation | 3 | 3 | 1 | 3 | 2 | 2.4 | 2 | 2 | 2 | 2.0 | 3 | 2 | 2.5 | 1 | 1 | 1.0 | 2 | | 2.0 | 1 | 2.3 | 1.5 | 2.0 |
| 8.4.2 Running | 3 | 3 | 1 | 1 | 2 | 2.0 | 2 | 3 | 2 | 2.3 | 2 | 3 | 2.5 | 1 | 1 | 1.0 | 2 | | 2.0 | 4 | 2.3 | 1.5 | 2.0 |
| 8.4.3 Maintenance | 3 | 3 | 1 | 1 | 4 | 2.4 | 2 | 2 | 2 | 2.0 | 2 | 1 | 1.5 | 1 | 1 | 1.0 | 2 | | 2.0 | 2 | 2.0 | 1.5 | 1.8 |

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## 9. Mechanical ventilation in open plan offices

| 9.1 Design | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.1.1 Easy of design | 4 | 5 | 3 | 5 | 4 | 4.2 | 4 | 2 | 4 | 3.3 | 4 | 2 | 3.0 | 3 | 2 | 2.5 | 2 | 2 | 2.0 | 3 | 3.5 | 2.3 | 3.0 |
| 9.1.2 Guidelines and advice | | 4 | 4 | 5 | 4 | 4.3 | 4 | 4 | 4 | 4.0 | 4 | 4 | 4.0 | 3 | 4 | 3.5 | 5 | 4 | 4.5 | 4 | 4.1 | 4.0 | 4.1 |
| 9.1.3 Products | 3 | 4 | 4 | 5 | 4 | 4.0 | 4 | 4 | 4 | 4.0 | 4 | 4 | 4.0 | 5 | 4 | 4.5 | 5 | 4 | 4.5 | 4 | 4.0 | 4.5 | 4.2 |
| 9.1.4 Flexibility | | 5 | 3 | 4 | 4 | 4.0 | 4 | 4 | 4 | 4.0 | 4 | 4 | 4.0 | 3 | 5 | 4.0 | 3 | 3 | 3.0 | 3 | 4.0 | 3.5 | 3.8 |
| 9.1.5 User satisfaction | 3 | 5 | 2 | 1 | 4 | 3.0 | 2 | 3 | 3 | 2.7 | 3 | 4 | 3.5 | 4 | 4 | 4.0 | 3 | 4 | 3.5 | 2 | 3.1 | 3.8 | 3.3 |

| 9.2 Performance in practice | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.2.1 Cooling effectiveness | 4 | 5 | 4 | 5 | 4 | 4.4 | 4 | 4 | 4 | 4.0 | 4 | 4 | 4.0 | 5 | 4 | 4.5 | 4 | 4 | 4.0 | 4 | 4.1 | 4.3 | 4.2 |
| 9.2.2 Draught minimisation | 3 | 4 | 2 | 2 | 4 | 3.0 | 3 | 3 | 4 | 3.3 | 3 | 4 | 3.5 | 3 | 3 | 3.0 | 4 | 2 | 3.0 | 3 | 3.3 | 3.0 | 3.2 |
| 9.2.3 Removal of odours/poll. | 4 | 4 | 4 | 5 | 4 | 4.2 | 4 | 4 | 4 | 4.0 | 3 | 4 | 3.5 | 5 | 4 | 4.5 | 4 | 4 | 4.0 | 4 | 3.9 | 4.3 | 4.0 |
| 9.2.4 Ingress of odours/poll. | 4 | 4 | 4 | 5 | 4 | 4.2 | 4 | 4 | 3 | 3.7 | 3 | 4 | 3.5 | 5 | 4 | 4.5 | 4 | 4 | 4.0 | 4 | 3.8 | 4.3 | 4.0 |
| 9.2.5 External noise | | 4 | 4 | 5 | 4 | 4.3 | 4 | 4 | 4 | 4.0 | 4 | 5 | 4.5 | 3 | 5 | 4.0 | 5 | 4 | 4.5 | 4 | 4.3 | 4.3 | 4.3 |
| 9.2.6 Internal noise | | 4 | 2 | 5 | 3 | 3.5 | 4 | 2 | 4 | 3.3 | 4 | 4 | 4.0 | 5 | 3 | 4.0 | 4 | 4 | 4.0 | 4 | 3.6 | 4.0 | 3.8 |

| 9.3 Control | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.3.1 Central | | 4 | 4 | 5 | 4 | 4.3 | 4 | 4 | 4 | 4.0 | 4 | 5 | 4.5 | 5 | 4 | 4.5 | 5 | 4 | 4.5 | 4 | 4.3 | 4.5 | 4.4 |
| 9.3.2 Local | | 4 | 4 | 5 | 4 | 4.3 | 2 | 4 | 4 | 3.3 | 3 | 4 | 3.5 | 5 | 4 | 4.5 | 1 | 2 | 1.5 | 3 | 3.7 | 3.0 | 3.4 |
| 9.3.3 Individual | | 4 | 2 | 2 | 1 | 2.3 | 1 | 2 | 3 | 2.0 | 3 | 4 | 3.5 | 1 | 1 | 1.0 | 1 | 1 | 1.0 | 2 | 2.6 | 1.0 | 2.0 |

| 9.4 Cost | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.4.1 Installation | 3 | 4 | 4 | 5 | 4 | 4.0 | 3 | 4 | 4 | 3.7 | 4 | 5 | 4.5 | 3 | 4 | 3.5 | 4 | 4 | 4.0 | 4 | 4.1 | 3.8 | 3.9 |
| 9.4.2 Running | 3 | 4 | 4 | 5 | 4 | 4.0 | 3 | 3 | 4 | 3.3 | 4 | 4 | 4.0 | 3 | 4 | 3.5 | 4 | 4 | 4.0 | 3 | 3.8 | 3.8 | 3.8 |
| 9.4.3 Maintenance | 3 | 4 | 4 | 5 | 3 | 3.8 | 3 | 4 | 4 | 3.7 | 4 | 3 | 3.5 | 3 | 4 | 3.5 | 4 | 4 | 4.0 | 4 | 3.7 | 3.8 | 3.7 |

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6. Natural ventilation in cellular offices

| 6.1 Design | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.1.1 Easy of design | 0 | 2 | -1 | 0 | -2 | -0.2 | 0 | 0 | -2 | -0.7 | -1 | 2 | 0.5 | 2 | 1 | 1.5 | -1 | 3 | 1.0 | 0 | -0.1 | 1.3 | 0.4 |
| 6.1.2 Guidelines and advice | | 0 | -2 | 0 | -2 | -1.0 | -1 | -3 | -3 | -2.3 | -2 | 0 | -1.0 | 2 | -2 | 0.0 | -2 | 1 | -0.5 | -1 | -1.4 | -0.3 | -1.0 |
| 6.1.3 Products | -1 | 0 | -3 | -3 | -2 | -1.8 | -1 | -4 | -3 | -2.7 | 1 | 0 | 0.5 | 0 | -2 | -1.0 | 0 | 1 | 0.5 | 0 | -1.3 | -0.3 | -0.9 |
| 6.1.4 Flexibility | | -1 | -2 | 1 | 1 | -0.3 | 0 | -2 | -3 | -1.7 | | -2 | -2.0 | 0 | 0 | 0.0 | 1 | 3 | 2.0 | -1 | -1.3 | 1.0 | -0.4 |
| 6.1.5 User satisfaction | 1 | 0 | 2 | 3 | 1 | 1.4 | -1 | 1 | 0 | 0.0 | 1 | -1 | 0.0 | 0 | 1 | 0.5 | -1 | 0 | -0.5 | 1 | 0.5 | 0.0 | 0.3 |

| 6.2 Performance in practice | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.2.1 Cooling effectiveness | 0 | -2 | -2 | 0 | -2 | -1.2 | -3 | -2 | -1 | -2.0 | 0 | -3 | -1.5 | -4 | -3 | -3.5 | -2 | -1 | -1.5 | -3 | -1.6 | -2.5 | -1.9 |
| 6.2.2 Draught minimisation | 1 | 0 | 2 | 3 | -2 | 0.8 | -2 | -2 | -1 | -1.7 | | 0 | 0.0 | -1 | 2 | 0.5 | 2 | -1 | 0.5 | 0 | -0.3 | 0.5 | 0.0 |
| 6.2.3 Removal of odours/poll. | 0 | 2 | 0 | 0 | -1 | 0.2 | -3 | 0 | -3 | -2.0 | 0 | 0 | 0.0 | -3 | 0 | -1.5 | 0 | -2 | -1.0 | 0 | -0.6 | -1.3 | -0.9 |
| 6.2.4 Ingress of odours/poll. | 0 | -2 | -2 | -2 | -2 | -1.6 | -3 | -2 | -2 | -2.3 | 1 | 0 | 0.5 | -3 | -2 | -2.5 | -3 | -2 | -2.5 | -1 | -1.1 | -2.5 | -1.7 |
| 6.2.5 External noise | | -1 | 0 | -2 | -3 | -1.5 | -3 | -2 | -3 | -2.7 | 0 | -1 | -0.5 | 2 | -1 | 0.5 | -3 | -3 | -3.0 | -2 | -1.6 | -1.3 | -1.4 |
| 6.2.6 Internal noise | | 0 | -1 | 3 | 1 | 0.8 | -1 | 2 | 0 | 0.3 | 0 | 0 | 0.0 | 1 | 1 | 1.0 | -1 | 1 | 0.0 | 0 | 0.4 | 0.5 | 0.4 |

| 6.3 Control | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.3.1 Central | | -2 | -3 | -2 | -3 | -2.5 | -2 | 0 | -3 | -1.7 | 1 | -1 | 0.0 | -4 | -2 | -3.0 | -4 | -3 | -3.5 | -2 | -1.4 | -3.3 | -2.1 |
| 6.3.2 Local | | 0 | 4 | 0 | 1 | 1.3 | 1 | -1 | -1 | -0.3 | 2 | -2 | 0.0 | -4 | 0 | -2.0 | -3 | 0 | -1.5 | 1 | 0.3 | -1.8 | -0.5 |
| 6.3.3 Individual | | 0 | 4 | 0 | 3 | 1.8 | 1 | 0 | 0 | 0.3 | 2 | -2 | 0.0 | 0 | 2 | 1.0 | -3 | 0 | -1.5 | 1 | 0.7 | -0.3 | 0.3 |

| 6.4 Cost | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.4.1 Installation | 0 | -2 | -1 | -2 | -2 | -1.4 | -1 | -2 | -2 | -1.7 | -1 | -3 | -2.0 | -3 | -3 | -3.0 | -3 | -3 | -3.0 | -3 | -1.7 | -3.0 | -2.2 |
| 6.4.2 Running | 0 | -2 | -2 | -2 | -2 | -1.6 | -1 | -1 | -2 | -1.3 | -2 | -1 | -1.5 | -2 | -2 | -2.0 | -3 | -2 | -2.5 | 2 | -1.5 | -2.3 | -1.8 |
| 6.4.3 Maintenance | 0 | -2 | -4 | -2 | 2 | -1.2 | -1 | -3 | -2 | -2.0 | -2 | -2 | -2.0 | -2 | -2 | -2.0 | -3 | -3 | -3.0 | -3 | -1.7 | -2.5 | -2.0 |

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### 8. Natural ventilation in open plan offices

| 8.1 Design | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.1.1 Easy of design | 0 | -3 | -2 | -3 | -2 | -2.0 | -3 | -1 | -2 | -2.0 | -2 | -1 | -1.5 | 2 | 0 | 1.0 | 0 | | 0.0 | -1 | -1.8 | 0.5 | -0.9 |
| 8.1.2 Guidelines and advice | | 0 | -3 | -3 | -2 | -2.0 | -3 | -3 | -2 | -2.7 | -2 | -3 | -2.5 | 2 | -1 | 0.5 | -1 | | -1.0 | -3 | -2.4 | -0.3 | -1.5 |
| 8.1.3 Products | -1 | 0 | -3 | -3 | -2 | -1.8 | -3 | -3 | -3 | -3.0 | 0 | -3 | -1.5 | 0 | -3 | -1.5 | -1 | | -1.0 | -3 | -2.1 | -1.3 | -1.8 |
| 8.1.4 Flexibility | | -1 | 1 | 0 | -2 | -0.5 | 0 | -2 | -2 | -1.3 | 0 | -2 | -1.0 | 0 | -4 | -2.0 | 1 | | 1.0 | -1 | -0.9 | -0.5 | -0.8 |
| 8.1.5 User satisfaction | 1 | -1 | 2 | 3 | | 1.3 | 0 | -1 | | -0.5 | 1 | | 1.0 | -3 | -2 | -2.5 | 1 | | 1.0 | 0 | 0.6 | -0.8 | 0.1 |

| 8.2 Performance in practice | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.2.1 Cooling effectiveness | 0 | -1 | -1 | -1 | -2 | -1.0 | -2 | -2 | -2 | -2.0 | 0 | -2 | -1.0 | -4 | -2 | -3.0 | -1 | | -1.0 | -2 | -1.3 | -2.0 | -1.6 |
| 8.2.2 Draught minimisation | 1 | -1 | 2 | 2 | -2 | 0.4 | -1 | -2 | -2 | -1.7 | 0 | -2 | -1.0 | -1 | -1 | -1.0 | 0 | | 0.0 | -1 | -0.8 | -0.5 | -0.7 |
| 8.2.3 Removal of odours/poll. | 0 | -3 | -2 | -3 | 0 | -1.6 | -2 | -1 | -2 | -1.7 | 1 | -2 | -0.5 | -3 | 0 | -1.5 | -1 | | -1.0 | -2 | -1.3 | -1.3 | -1.3 |
| 8.2.4 Ingress of odours/poll. | 0 | -2 | -2 | -3 | -2 | -1.8 | -2 | -2 | -2 | -2.0 | -1 | -1 | -1.0 | -3 | -1 | -2.0 | -2 | | -2.0 | -1 | -1.6 | -2.0 | -1.8 |
| 8.2.5 External noise | | 0 | -2 | -1 | -2 | -1.3 | -2 | -2 | -2 | -2.0 | -1 | -1 | -1.0 | 2 | -2 | 0.0 | -2 | | -2.0 | -2 | -1.4 | -1.0 | -1.3 |
| 8.2.6 Internal noise | | 0 | 2 | -1 | -1 | 0.0 | 0 | 2 | -1 | 0.3 | -1 | 1 | 0.0 | -1 | 0 | -0.5 | 0 | | 0.0 | 0 | 0.1 | -0.3 | 0.0 |

| 8.3 Control | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.3.1 Central | | -2 | -2 | -1 | -2 | -1.8 | -2 | 0 | -3 | -1.7 | 0 | -1 | -0.5 | -4 | -3 | -3.5 | -3 | | -3.0 | -3 | -1.3 | -3.3 | -2.1 |
| 8.3.2 Local | | -2 | 0 | -1 | -1 | -1.0 | 1 | 0 | -1 | 0.0 | 1 | -2 | -0.5 | -4 | -3 | -3.5 | 1 | | 1.0 | 1 | -0.5 | -1.3 | -0.8 |
| 8.3.3 Individual | | -3 | 0 | 2 | 0 | -0.3 | 1 | -1 | -1 | -0.3 | 0 | -2 | -1.0 | 0 | 0 | 0.0 | 1 | | 1.0 | 0 | -0.5 | 0.5 | -0.1 |

| 8.4 Cost | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.4.1 Installation | 0 | -1 | -3 | -2 | -2 | -1.6 | -1 | -2 | -2 | -1.7 | -1 | -3 | -2.0 | -2 | -3 | -2.5 | -2 | | -2.0 | -3 | -1.8 | -2.3 | -2.0 |
| 8.4.2 Running | 0 | -1 | -3 | -4 | -2 | -2.0 | -1 | 0 | -2 | -1.0 | -2 | -1 | -1.5 | -2 | -3 | -2.5 | -2 | | -2.0 | 1 | -1.5 | -2.3 | -1.8 |
| 8.4.3 Maintenance | 0 | -1 | -3 | -4 | 1 | -1.4 | -1 | -2 | -2 | -1.7 | -2 | -2 | -2.0 | -2 | -3 | -2.5 | -2 | | -2.0 | -2 | -1.7 | -2.3 | -1.9 |

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### 8. Natural ventilation in open plan offices

| 8.1 Design | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.1.1 Easy of design | 0 | -3 | -2 | -2 | 0 | -1.4 | -2 | -3 | 0 | -1.7 | -2 | -4 | -3.0 | 0 | -2 | -1.0 | 0 | | 0.0 | -2 | -2.0 | -0.5 | -1.4 |
| 8.1.2 Guidelines and advice | | 0 | -1 | -3 | 0 | -1.0 | -1 | 0 | 0 | -0.3 | 0 | -4 | -2.0 | 0 | 1 | 0.5 | 2 | | 2.0 | -2 | -1.1 | 1.3 | -0.2 |
| 8.1.3 Products | 0 | 0 | 0 | 0 | 0 | 0.0 | -1 | 0 | -1 | -0.7 | -1 | -4 | -2.5 | 0 | -1 | -0.5 | 0 | | 0.0 | -3 | -1.1 | -0.3 | -0.7 |
| 8.1.4 Flexibility | | 1 | 2 | -1 | -2 | 0.0 | 1 | 0 | 0 | 0.3 | | 0 | 0.0 | 0 | -3 | -1.5 | 0 | | 0.0 | -1 | 0.1 | -0.8 | -0.2 |
| 8.1.5 User satisfaction | 0 | 0 | 0 | -1 | | -0.3 | -1 | -2 | | -1.5 | 0 | | 0.0 | -3 | -2 | -2.5 | 1 | | 1.0 | -2 | -0.6 | -0.8 | -0.7 |

| 8.2 Performance in practice | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.2.1 Cooling effectiveness | 0 | 2 | 1 | 0 | 0 | 0.6 | 1 | 0 | -2 | -0.3 | 0 | 0 | 0.0 | 0 | 1 | 0.5 | 1 | | 1.0 | 0 | 0.1 | 0.8 | 0.4 |
| 8.2.2 Draught minimisation | 0 | -1 | 0 | 0 | 0 | -0.2 | 0 | -1 | -2 | -1.0 | | -2 | | 0 | -2 | -1.0 | 0 | | 0.0 | -1 | -0.6 | -0.5 | -0.6 |
| 8.2.3 Removal of odours/poll. | 0 | -3 | -2 | -2 | 1 | -1.2 | 0 | -1 | 0 | -0.3 | 0 | -2 | -1.0 | 0 | 0 | 0.0 | -1 | | -1.0 | -2 | -0.8 | -0.5 | -0.7 |
| 8.2.4 Ingress of odours/poll. | 0 | 0 | 0 | 0 | 0 | 0.0 | 0 | 0 | -1 | -0.3 | -2 | -1 | -1.5 | 0 | 1 | 0.5 | 0 | | 0.0 | 0 | -0.6 | 0.3 | -0.3 |
| 8.2.5 External noise | | 1 | -2 | 2 | 1 | 0.5 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 1 | | 1.0 | 0 | 0.2 | 0.5 | 0.3 |
| 8.2.6 Internal noise | | 0 | 2 | 0 | -2 | 0.0 | 1 | 0 | -1 | 0.0 | -1 | 1 | 0.0 | 0 | -1 | -0.5 | 0 | | 0.0 | 0 | 0.0 | -0.3 | -0.1 |

| 8.3 Control | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.3.1 Central | | 0 | 0 | 2 | 1 | 0.8 | 0 | 0 | -1 | -0.3 | -1 | 0 | -0.5 | 0 | -1 | -0.5 | 1 | | 1.0 | 0 | 0.0 | 0.3 | 0.1 |
| 8.3.2 Local | | -2 | -1 | 0 | -1 | -1.0 | 0 | 1 | 0 | 0.3 | 0 | 0 | 0.0 | 0 | -3 | -1.5 | 0 | | 0.0 | 0 | -0.2 | -0.8 | -0.4 |
| 8.3.3 Individual | | -3 | -3 | 0 | -3 | -2.3 | -1 | -3 | -2 | -2.0 | -1 | 0 | -0.5 | -2 | -3 | -2.5 | 0 | | 0.0 | -2 | -1.6 | -1.3 | -1.5 |

| 8.4 Cost | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.4.1 Installation | 0 | 1 | -1 | 1 | 0 | 0.2 | 0 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 1 | | 1.0 | 0 | 0.1 | 0.5 | 0.2 |
| 8.4.2 Running | 0 | 1 | -1 | -1 | 1 | 0.0 | 0 | 1 | 0 | 0.3 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 1 | | 1.0 | 0 | 0.1 | 0.5 | 0.3 |
| 8.4.3 Maintenance | 0 | 1 | 0 | -1 | 2 | 0.4 | 0 | 1 | 0 | 0.3 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 1 | | 1.0 | 1 | 0.2 | 0.5 | 0.3 |

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| 3. Knowledge | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All ex. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.1 Mechanical ventilation | 2 | 3 | 3 | 5 | 4 | 3.4 | 4 | 4 | 5 | 4.3 | 1 | 5 | 3.0 | 5 | 4 | 4.5 | 4 | 3 | 3.5 | 3 | 3.6 | 4.0 | 3.7 |
| 3.1.1 Heat recovery | 2 | 3 | 4 | 4 | 3 | 3.2 | 4 | 4 | 5 | 4.3 | 2 | 5 | 3.5 | 5 | 4 | 4.5 | 4 | 2 | 3.0 | 4 | 3.7 | 3.8 | 3.7 |
| 3.1.2 Mechanical cooling | 2 | 3 | 4 | 2 | 4 | 3.0 | 3 | 3 | 5 | 3.7 | 1 | 5 | 3.0 | 5 | 4 | 4.5 | 4 | 2 | 3.0 | 3 | 3.2 | 3.8 | 3.4 |
| 3.2 Ordinary natural ventilation | 2 | 3 | 4 | 4 | 4 | 3.4 | 4 | 2 | 3 | 3.0 | 2 | 2 | 2.0 | 5 | 4 | 4.5 | 4 | 3 | 3.5 | 3 | 2.8 | 4.0 | 3.3 |
| 3.3 Spec. des. natural ventilation | 2 | 4 | 5 | 2 | 1 | 2.8 | 3 | 2 | 4 | 3.0 | 2 | 1 | 1.5 | 4 | 2 | 3.0 | 3 | 1 | 2.0 | 2 | 2.4 | 2.5 | 2.5 |
| Compared to mechanical ventilation: | | | | | | | | | | | | | | | | | | | | | | | |
| 3.1.1 Heat recovery | 0 | 0 | 1 | -1 | -1 | -0.2 | 0 | 0 | 0 | 0.0 | 1 | 0 | 0.5 | 0 | 0 | 0.0 | 0 | -1 | -0.5 | 1 | 0.1 | -0.3 | 0.0 |
| 3.1.2 Mechanical cooling | 0 | 0 | 1 | -3 | 0 | -0.4 | -1 | -1 | 0 | -0.7 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 0 | -1 | -0.5 | 0 | -0.4 | -0.3 | -0.3 |
| 3.2 Ordinary natural ventilation | 0 | 0 | 1 | -1 | 0 | 0.0 | 0 | -2 | -2 | -1.3 | 1 | -3 | -1.0 | 0 | 0 | 0.0 | 0 | 0 | 0.0 | 0 | -0.8 | 0.0 | -0.5 |
| 3.3 Spec. des. natural ventilation | 0 | 1 | 2 | -3 | -3 | -0.6 | -1 | -2 | -1 | -1.3 | 1 | -4 | -1.5 | -1 | -2 | -1.5 | -1 | -2 | -1.5 | -1 | -1.1 | -1.5 | -1.3 |

| 4. Experience | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New office buildings: | | | | | | | | | | | | | | | | | | | | | | | |
| 4.1.1 Mechanical ventilation | 33 | 40 | 20 | 0 | 20 | 23 | 50 | 70 | 80 | 67 | 0 | 33 | 17 | 90 | 20 | 55 | 95 | 30 | 63 | | 35 | 59 | 45 |
| 4.1.2 Ordinary natural ventilation | 66 | 40 | 40 | 100 | 80 | 65 | 50 | 30 | 0 | 27 | 100 | 67 | 84 | 7 | 80 | 44 | 5 | 70 | 38 | | 58 | 41 | 51 |
| 4.1.3 Spec. des. natural ventilation | 0 | 20 | 40 | 0 | 0 | 12 | 0 | 0 | 20 | 7 | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | | 6 | 1 | 4 |
| Refurbished office buildings: | | | | | | | | | | | | | | | | | | | | | | | |
| 4.2.1 Mechanical ventilation | 33 | 30 | 20 | 0 | 10 | 19 | 20 | 70 | 80 | 57 | 0 | 50 | 25 | | 0 | 0 | | | | | 33 | 0 | 25 |
| 4.2.2 Ordinary natural ventilation | 66 | 70 | 80 | 100 | 90 | 81 | 80 | 30 | 0 | 37 | 100 | 50 | 75 | | 100 | 100 | | | | | 64 | 100 | 73 |
| 4.2.3 Spec. des. natural ventilation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 7 | 0 | 0 | 0 | | 0 | 0 | | | | | 2 | 0 | 2 |

| 5. Project fee | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.1 Fixed fee | 75 | 50 | 0 | 0 | 5 | 26 | 50 | 50 | 40 | 47 | 100 | 100 | 100 | 0 | 80 | 40 | | | | | 36 |
| 5.2 Percentage of construction costs | 25 | 50 | 100 | 100 | 90 | 73 | 50 | 25 | 40 | 38 | 0 | 0 | 0 | 100 | 20 | 60 | | | | | 56 |
| 5.3 Per hour | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 25 | 20 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 8 |
| 5.4 Other | | | | | | | | | | | | | | | | | | | | | |

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| 10. Source to nat. vent. knowledge | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N= | | | | | | 5 | | | | 3 | | | 2 | | | 2 | | | 2 | | | | |
| 10.1 Standards | | 1 | | | | 20 | 1 | | | 33 | | | 0 | | 1 | 50 | | | 0 | | 18 | 25 | 21 |
| 10.2 Guidelines | | | | | | 0 | 1 | | | 33 | | | 0 | | | 0 | | | 0 | | 11 | 0 | 7 |
| 10.3 Buildings studies | | 1 | 1 | 1 | | 60 | 1 | | 1 | 67 | | | 0 | | | 0 | | | 0 | | 42 | 0 | 25 |
| 10.4 Experience | 1 | 1 | | | 1 | 60 | 1 | 1 | 1 | 100 | 1 | | 50 | | 1 | 50 | | 1 | 50 | 1 | 70 | 50 | 62 |
| 10.5 Own design | 1 | 1 | 1 | 1 | | 80 | 1 | | 1 | 67 | | | 0 | | | 0 | | | 0 | | 49 | 0 | 29 |
| 10.6 Other | 1 | | | 1 | | 40 | 1 | 1 | | 67 | 1 | 1 | 100 | 1 | | 50 | 1 | 1 | 100 | | 69 | 75 | 71 |

| 11. Future use of natural ventilation | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 Future use | 4 | 5 | 5 | 5 | 5 | 4.8 | 3 | 3 | 4 | 3.3 | 4 | 4 | 4.0 | 3 | 4 | 3.5 | 4 | 4 | 4.0 | 2 | 4.0 | 3.8 | 3.9 |

| 12. Restricting requirements | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | AEC | DO | All |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 Restrictions | 2 | 2 | 4 | 4 | 3 | 3.0 | 2 | 1 | 3 | 2.0 | 1 | 2 | 1.5 | 1 | 1 | 1.0 | 1 | 1 | 1.0 | 1 | 2.2 | 1.0 | 1.7 |

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| Switzerland, January 3. 1997 | mis | ok | ok | ok | ok | | ok | ok | ok | | ok | ok | | ok | ok | | ok | ok | | mis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. The design: Offices | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
| | | | | | | | | | | | | | | | | | | | | | | 13 |
| 3.1 Ventilation system | | | | | | | | | | | | | | | | | | | | | | |
| 3.1.1 Mechanical ventilation | | 1 | | | | | 1 | 1 | 1 | | | 1 | | 1 | | | | | | | 0.46 | |
| 3.1.2 Mechanical exhaust | | | | | | | | | | | | | | | | | | 1 | | | 0.08 | |
| 3.1.3 Natural ventilation | | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | | | | 1 | | 1 | | | | 0.69 | |
| 3.1.4 Heat recovery | | 1 | | 1 | | | 1 | 1 | 1 | | | 1 | | 1 | | | | | | | 0.54 | |
| 3.1.5 Night time ventilation | | 1 | 1 | 1 | | | 1 | 1 | 1 | | | | | | | | | | | | 0.46 | |
| 3.2 Mechanical cooling | | | | | | | | | | | | | | | | | | | | | | |
| 3.2.1 In ventilation system | | 1 | 1 | | | | | | 1 | | | | | | | | | | | | 0.23 | |
| 3.2.2 Cooled ceilings | | | | | | | | | | | | | | 1 | | | | | | | 0.08 | |
| 3.3 External openings | | | | | | | | | | | | | | | | | | | | | | |
| 3.3.1 Ordinary windows | | 1 | | 1 | 1 | | 1 | 1 | 1 | | 1 | 1 | | | 1 | | 1 | 1 | | | 0.85 | |
| 3.3.2 Special ventilation windows | | | 1 | | | | | | | | 1 | | | | | | | | | | 0.15 | |
| 3.3.3 Ordinary vents | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.4 Advanged vents | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.5 Stack ducts | | | | | | | | 1 | | | | | | 1 | | | | | | | 0.15 | |
| 3.3.6 Ventilation chimney | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.7 Roof openings | | | | | | | | 1 | | | | | | | | | | | | | 0.08 | |
| 3.3.8 Ducted air supply | | 1 | | | | | 1 | 1 | 1 | | | | | 1 | | | | | | | 0.38 | |
| 3.4 Int. horizontal air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.4.1 Doors | | 1 | | 1 | | | | | 1 | | 1 | | | | | | 1 | 1 | | | 0.46 | |
| 3.4.2 Ventilation openings | | | | | | | | 1 | | | | | | | | | | | | | 0.08 | |
| 3.4.3 Open connection | | | 1 | | | | | | | | | | | | | | | | | | 0.08 | |
| 3.5 Int. vertical air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.5.1 Ventilation openings | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.5.2 Open connection | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.6 Solar shading | | | | | | | | | | | | | | | | | | | | | | |
| 3.6.1 Internal | | | | | | | | | | | 1 | | | | | | | | | | 0.08 | |
| 3.6.2 Between panes | | | 1 | | | | | | | | | | | | | | | | | | 0.08 | |
| 3.6.3 External | | 1 | | 1 | 1 | | 1 | 1 | 1 | | | 1 | | | 1 | | 1 | 1 | | | 0.77 | |

| | | | |
|---|---|---|---|
| 3.6.4 Protective glazing | 1 | 1 | 0.15 |

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| Switzerland, January 3. 1997 | mi | ok | ok | ok | ok | | ok | ok | ok | | ok | ok | | ok | ok | | ok | ok | | mis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. The design: Offices | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | |
| 3.7 Ceilings | | | | | | | | | | | | | | | | | | | | | | |
| 3.7.1 High ceilings | | | 1 | | | | 1 | 1 | | | | | | | | | | 1 | | | 0.31 | |
| 3.7.2 False ceilings | | | | | 1 | | 1 | | | | 1 | 1 | | | 1 | | | | | | 0.38 | |
| 3.7.3 Exposed heavy structure | | 1 | 1 | 1 | | | 1 | 1 | 1 | | | | | 1 | | | 1 | 1 | | | 0.69 | |
| 3.8 Floor and walls | | | | | | | | | | | | | | | | | | | | | | |
| 3.8.1 Exposed heavy floor | | | | | | | 1 | 1 | 1 | | 1 | | | 1 | | | 1 | 1 | | | 0.54 | |
| 3.8.2 Exposed heavy internal walls | | | 1 | | 1 | | 1 | | | | 1 | | | 1 | | | 1 | 1 | | | 0.54 | |
| 3.8.3 Exposed heavy external walls | | 1 | | 1 | 1 | | 1 | | 1 | | 1 | | | | 1 | | | 1 | | | 0.62 | |
| 4. Background: Offices | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
| | | | | | | | | | | | | | | | | | | mis | | | | 12 |
| 4.1 Room temp., winter | | | | | | | | | 5 | | 1 | | | 5 | | | 5 | | | | 1.33 | |
| 4.2 Indoor air quality | | 3 | | 5 | | | 3 | | 1 | | 3 | | | 4 | | | | | | | 1.58 | |
| 4.3 Draught, winter | | | | | | | | | 3 | | | | | | | | 3 | | | | 0.50 | |
| 4.4 Room temp., summer | | | 2 | 2 | 5 | | | | 4 | | 5 | | | | | | 5 | | | | 1.92 | |
| 4.5 Solar loads | | | | | 4 | | | | | | 4 | | | | | | | | | | 0.67 | |
| 4.6 Internal heat loads | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.7 Draught, summer | | | | 1 | | | | | | | | | | | | | 2 | | | | 0.25 | |
| 4.8 Individual control | | | 1 | | 3 | | | | | | 2 | | | | | | 4 | | | | 0.83 | |
| 4.9 Internal noise | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.10 External noise | | 5 | | | | | 5 | | 1 | | | 5 | | | | | 1 | | | | 1.42 | |
| 4.11 Internal air pollution/odours | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.12 External air pollution/odours | | 4 | | | | | 4 | | | | | 4 | | | | | | | | | 1.00 | |
| 4.13 Fire regulations | | | | | | | | | | | | | | 2 | | | | | | | 0.17 | |
| 4.14 Security | | | | | | | | | | | | | | 1 | | | | | | | 0.08 | |
| 4.15 Construction costs | | | 5 | 4 | 2 | | | 4 | | | | 3 | | 3 | 5 | | 2 | | | | 2.33 | |
| 4.16 Operating costs | | | 4 | 3 | | | | 2 | | | | | | | 4 | | | | | | 1.08 | |
| 4.17 Maintenance costs | | | 3 | 3 | 1 | | | | | | | | | | | | | | | | 0.58 | |
| 4.18 Others | | 2 | | | | | | 5 | | | | | | | | | | | | | 0.58 | |

| Switzerland, January 3. 1997 | mi | ok | ok | ok | ok | | ok | ok | ok | | ok | ok | | ok | ok | | ok | ok | | mis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. The design: Meeting rooms | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
| | | | | | | | | | | | | mis | | | | | | mis | | | | 11 |
| 3.1 Ventilation system | | | | | | | | | | | | | | | | | | | | | | |
| 3.1.1 Mechanical ventilation | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | | | | | 0.82 | |
| 3.1.2 Mechanical exhaust | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.1.3 Natural ventilation | | | | 1 | | | 1 | | | | 1 | | | | | | 1 | | | | 0.36 | |
| 3.1.4 Heat recovery | | 1 | | 1 | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | | | | | 0.73 | |
| 3.1.5 Night time ventilation | | | | 1 | | | 1 | 1 | | | | | | | | | | | | | 0.27 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.2 Mechanical cooling | | | | | | | | | | | | | | | | | | | | | | |
| 3.2.1 In ventilation system | | 1 | | | 1 | | | | 1 | | | | | | | | | | | | 0.27 | |
| 3.2.2 Cooled ceilings | | | | | | | | | | | | | | 1 | 1 | | | | | | 0.18 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 External openings | | | | | | | | | | | | | | | | | | | | | | |
| 3.3.1 Ordinary windows | | | | 1 | 1 | | 1 | 1 | | | 1 | | | | | | 1 | | | | 0.55 | |
| 3.3.2 Special ventilation windows | | | | | | | | | | | 1 | | | | | | | | | | 0.09 | |
| 3.3.3 Ordinary vents | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.4 Advanged vents | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.5 Stack ducts | | | | | | | | 1 | | | | | | 1 | | | | | | | 0.18 | |
| 3.3.6 Ventilation chimney | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.7 Roof openings | | | | | | | | 1 | | | | | | | | | | | | | 0.09 | |
| 3.3.8 Ducted air supply | | 1 | 1 | | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | | | | | 0.73 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.4 Int. horizontal air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.4.1 Doors | | 1 | | 1 | 1 | | | | 1 | | 1 | | | | | | 1 | | | | 0.55 | |
| 3.4.2 Ventilation openings | | | | | | | | 1 | | | | | | | | | | | | | 0.09 | |
| 3.4.3 Open connection | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.5 Int. vertical air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.5.1 Ventilation openings | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.5.2 Open connection | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.6 Solar shading | | | | | | | | | | | | | | | | | | | | | | |
| 3.6.1 Internal | | | | | | | | | | | 1 | | | | | | | | | | 0.09 | |
| 3.6.2 Between panes | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.6.3 External | | | | 1 | 1 | | 1 | 1 | | | | | | | 1 | | 1 | | | | 0.55 | |

| | | |
|---|---|---|
| 3.6.4 Protective glazing | 1 | 0.09 |

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| Switzerland, January 3. 1997 | mi | ok | ok | ok | ok | | ok | ok | ok | | ok | ok | | ok | ok | | ok | ok | | mis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. The design: Meeting rooms | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | |
| 3.7 Ceilings | | | | | | | | | | | | | | | | | | | | | | |
| 3.7.1 High ceilings | | | 1 | | | | 1 | 1 | | | | | | | | | | | | | 0.27 | |
| 3.7.2 False ceilings | | | | | 1 | | 1 | | | | | | | | 1 | | | | | | 0.27 | |
| 3.7.3 Exposed heavy structure | | 1 | 1 | 1 | | | 1 | 1 | 1 | | 1 | | | 1 | | | 1 | | | | 0.82 | |
| 3.8 Floor and walls | | | | | | | | | | | | | | | | | | | | | | |
| 3.8.1 Exposed heavy floor | | | | | | | 1 | 1 | | | 1 | | | 1 | | | 1 | | | | 0.45 | |
| 3.8.2 Exposed heavy internal walls | | | 1 | | | | 1 | | | | 1 | | | 1 | | | 1 | | | | 0.45 | |
| 3.8.3 Exposed heavy external walls | | | | 1 | | | 1 | | | | 1 | | | | 1 | | | | | | 0.36 | |
| 4. Background: Meeting rooms | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
| | | | | | | | | | | | | | | | | | | mis | | | | 12 |
| 4.1 Room temp., winter | | | | | | | | | 5 | | 1 | | | 5 | | | 5 | | | | 1.33 | |
| 4.2 Indoor air quality | | 3 | 4 | 5 | | | 3 | | 3 | | 3 | | | 4 | | | 4 | | | | 2.42 | |
| 4.3 Draught, winter | | | | | | | | | 2 | | | | | | | | 2 | | | | 0.33 | |
| 4.4 Room temp., summer | | | 3 | 2 | 5 | | | | 4 | | 5 | | | 3 | | | 3 | | | | 2.08 | |
| 4.5 Solar loads | | | | | 4 | | | | | | 4 | | | | | | | | | | 0.67 | |
| 4.6 Internal heat loads | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.7 Draught, summer | | | | 1 | | | | | | | | | | | | | 1 | | | | 0.17 | |
| 4.8 Individual control | | | | | 3 | | | | | | 2 | | | | | | 3 | | | | 0.67 | |
| 4.9 Internal noise | | | | | | | | | 1 | | | | | | | | | | | | 0.08 | |
| 4.10 External noise | | 5 | | | | | 5 | | | | | | | | | | | | | | 0.83 | |
| 4.11 Internal air pollution/odours | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.12 External air pollution/odours | | 4 | | | | | 4 | | | | | | | | | | | | | | 0.67 | |
| 4.13 Fire regulations | | | | | | | | | | | | | | 1 | | | | | | | 0.08 | |
| 4.14 Security | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.15 Construction costs | | | | 4 | 2 | | | 4 | | | | | | 2 | 5 | | | | | | 1.42 | |
| 4.16 Operating costs | | | 2 | 3 | | | | 2 | | | | | | | 4 | | | | | | 0.92 | |
| 4.17 Maintenance costs | | | 1 | 3 | 1 | | | | | | | | | | | | | | | | 0.42 | |
| 4.18 Others | | 2 | 5 | | | | | 5 | | | | | | | | | | | | | 1.00 | |

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| Switzerland, January 3. 1997 | mi | ok | ok | ok | ok | | ok | ok | ok | | ok | ok | | ok | ok | | ok | ok | | mis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. The design: Canteen | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
| | | | | mis | | | | | | | mis | mis | | | | | mis | | | | | 9 |
| 3.1 Ventilation system | | | | | | | | | | | | | | | | | | | | | | |
| 3.1.1 Mechanical ventilation | | 1 | 1 | | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | | 1 | | | 1.00 | |
| 3.1.2 Mechanical exhaust | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.1.3 Natural ventilation | | | | | | | 1 | | | | | | | | | | | | | | 0.11 | |
| 3.1.4 Heat recovery | | 1 | | | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | | | | | 0.78 | |
| 3.1.5 Night time ventilation | | | | | | | 1 | 1 | | | | | | | | | | | | | 0.22 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.2 Mechanical cooling | | | | | | | | | | | | | | | | | | | | | | |
| 3.2.1 In ventilation system | | | | | 1 | | | | | | | | | | | | | 1 | | | 0.22 | |
| 3.2.2 Cooled ceilings | | | | | | | | | | | | | | 1 | | | | | | | 0.11 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.3 External openings | | | | | | | | | | | | | | | | | | | | | | |
| 3.3.1 Ordinary windows | | | 1 | | 1 | | 1 | 1 | | | | | | | | | | 1 | | | 0.56 | |
| 3.3.2 Special ventilation windows | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.3 Ordinary vents | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.4 Advanged vents | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.5 Stack ducts | | | | | | | | 1 | | | | | | 1 | | | | | | | 0.22 | |
| 3.3.6 Ventilation chimney | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.7 Roof openings | | | | | | | | 1 | | | | | | | | | | | | | 0.11 | |
| 3.3.8 Ducted air supply | | 1 | 1 | | 1 | | 1 | 1 | 1 | | | | | 1 | 1 | | | | | | 0.89 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.4 Int. horizontal air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.4.1 Doors | | 1 | | | | | | | | | | | | | | | | | | | 0.11 | |
| 3.4.2 Ventilation openings | | | | | | | | 1 | | | | | | | | | | | | | 0.11 | |
| 3.4.3 Open connection | | | | | | | | | | | | | | 1 | | | | | | | 0.11 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.5 Int. vertical air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.5.1 Ventilation openings | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.5.2 Open connection | | | | | 1 | | | | | | | | | | | | | | | | 0.11 | |
| | | | | | | | | | | | | | | | | | | | | | | |
| 3.6 Solar shading | | | | | | | | | | | | | | | | | | | | | | |
| 3.6.1 Internal | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.6.2 Between panes | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.6.3 External | | | 1 | | 1 | | 1 | 1 | | | | | | | 1 | | | | | | 0.56 | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.6.4 Protective glazing | | | | | | | | | | | | | | | 1 | | | | | | 0.11 |
| Switzerland, January 3. 1997 | mi | ok | ok | ok | ok | | ok | ok | ok | | ok | ok | | ok | ok | | ok | ok | | mis | |
| 3. The design: Canteen | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All |
| 3.7 Ceilings | | | | | | | | | | | | | | | | | | | | | |
| 3.7.1 High ceilings | | | 1 | | 1 | | 1 | 1 | | | | | | | | | | | | | 0.44 |
| 3.7.2 False ceilings | | | | | | | 1 | | | | | | | 1 | 1 | | 1 | 1 | | | 0.56 |
| 3.7.3 Exposed heavy structure | | | 1 | | 1 | | | 1 | | | | | | | | | | | | | 0.33 |
| 3.8 Floor and walls | | | | | | | | | | | | | | | | | | | | | |
| 3.8.1 Exposed heavy floor | | 1 | | | | | 1 | 1 | 1 | | | | | 1 | | | | 1 | | | 0.67 |
| 3.8.2 Exposed heavy internal walls | | 1 | 1 | | | | 1 | | 1 | | | | | 1 | | | | 1 | | | 0.67 |
| 3.8.3 Exposed heavy external walls | | | | | | | 1 | | | | | | | | | | 1 | 1 | | | 0.33 |

| 4. Background: Canteen | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | mis | | | | | | | mis | mis | | | | | mis | mis | | | | 8 |
| 4.1 Room temp., winter | | | | | | | | | 5 | | | | | | | | | | | | 0.63 | |
| 4.2 Indoor air quality | | 3 | 5 | | 5 | | 3 | | 4 | | | | | 3 | | | | | | | 2.88 | |
| 4.3 Draught, winter | | | | | | | | | 3 | | | | | | | | | | | | 0.38 | |
| 4.4 Room temp., summer | | | | | 4 | | | | 1 | | | | | | | | | | | | 0.63 | |
| 4.5 Solar loads | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.6 Internal heat loads | | | 4 | | | | | | | | | | | | | | | | | | 0.50 | |
| 4.7 Draught, summer | | | | | 3 | | | | | | | | | | | | | | | | 0.38 | |
| 4.8 Individual control | | | 3 | | | | | | | | | | | | | | | | | | 0.38 | |
| 4.9 Internal noise | | | | | | | | | 2 | | | | | | | | | | | | 0.25 | |
| 4.10 External noise | | 5 | | | | | 5 | | | | | | | | | | | | | | 1.25 | |
| 4.11 Internal air pollution/odours | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 4.12 External air pollution/odours | | 4 | | | | | 4 | | | | | | | | | | | | | | 1.00 | |
| 4.13 Fire regulations | | | | | | | | | | | | | | 4 | | | | | | | 0.50 | |
| 4.14 Security | | | | | | | | | | | | | | 5 | | | | | | | 0.63 | |
| 4.15 Construction costs | | | | | 2 | | | 4 | | | | | | | 5 | | | | | | 1.38 | |
| 4.16 Operating costs | | | 2 | | | | | 2 | | | | | | | 4 | | | | | | 1.00 | |
| 4.17 Maintenance costs | | | 1 | | 1 | | | | | | | | | | | | | | | | 0.25 | |
| 4.18 Others | | 2 | | | | | | 5 | | | | | | | | | | | | | 0.88 | |

| Switzerland, January 3. 1997 | mi | ok | ok | ok | ok | | ok | ok | ok | | ok | ok | | ok | ok | | ok | ok | | mis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. The design: Community areas | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
| | | | | | | | | | | | | | | | | | | | | | | 13 |
| 3.3 External openings | | | | | | | | | | | | | | | | | | | | | | |
| 3.3.2 Special ventilation windows | | 1 | 1 | | | | | | | | | | | | | | | | | | 0.15 | |
| 3.3.4 Advanged vents | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.3.5 Stack ducts | | 1 | | | | | | | | | | | | 1 | | | | | | | 0.15 | |
| 3.3.6 Ventilation chimney | | | 1 | | | | | | | | 1 | | | | | | | | | | 0.15 | |
| 3.3.7 Roof openings | | 1 | 1 | 1 | | | 1 | | | | 1 | | | 1 | | | | | | | 0.46 | |
| 3.3.8 Ducted air supply | | 1 | | | | | | | | | | | | 1 | 1 | | | | | | 0.23 | |
| 3.4 Int. horizontal air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.4.2 Ventilation openings | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.4.3 Open connection | | 1 | 1 | | | | | | 1 | | | | | 1 | | | | | | | 0.31 | |
| 3.5 Int. vertical air flow | | | | | | | | | | | | | | | | | | | | | | |
| 3.5.1 Ventilation openings | | | | | | | | | | | | | | | | | | | | | 0.00 | |
| 3.5.2 Open connection | | | 1 | 1 | 1 | | 1 | | | | 1 | | | 1 | | | | 1 | | | 0.54 | |

| 3. The design: Lavatories | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | 13 |
| 3.1 Ventilation system | | | | | | | | | | | | | | | | | | | | | | |
| 3.1.1 Mechanical ventilation | | | 1 | | 1 | | | | | | | | | | 1 | | | | | | 0.23 | |
| 3.1.2 Mechanical exhaust | | 1 | | 1 | | | 1 | 1 | 1 | | | 1 | | 1 | | | 1 | 1 | | | 0.69 | |
| 3.1.3 Natural ventilation | | | | | | | | | | | 1 | | | | | | | | | | 0.08 | |
| 3.1.4 Heat recovery | | | | | 1 | | | 1 | | | | 1 | | | | | | | | | 0.23 | |
| 3.1.5 Night time ventilation | | | | | | | | 1 | | | | | | | 1 | | | | | | 0.15 | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5. Biggest influence on chosen desig | A1 | A2 | A3 | A4 | A5 | A | E1 | E2 | E3 | E | C1 | C2 | C | D1 | D2 | D | O1 | O2 | O | G | All | N |
| | | | | | | | | | | | | | | | mis | | | mis | | | | 11 |
| 5.1 Architect | | 5 | 5 | 5 | 5 | | 5 | 4 | 4 | | | 2 | | 3 | 4 | | 3 | | | | 4.09 | |
| 5.2 Consultant engineer | | | 3 | | 2 | | 4 | 5 | 2 | | | 3 | | 2 | 3 | | | | | | 2.18 | |
| 5.3 Contractor | | | 2 | | | | | | | | | | | | 3 | | | | | | 0.45 | |
| 5.4 Owner | | 3 | | 1 | 3 | | | | 3 | | 5 | 5 | | 4 | | | 5 | | | | 2.64 | |
| 5.5 Developer | | | | | | | | | | | 4 | | | | | | | | | | 0.36 | |
| 5.6 Investor | | | 4 | | | | | | | | 2 | | | | 5 | | | | | | 1.00 | |
| 5.7 Users | | | | 2 | | | | | 1 | | 3 | 5 | | | 1 | | | | | | 1.09 | |
| 5.8 The building site | | | | 4 | 4 | | | | 5 | | | 1 | | | | | | | | | 1.27 | |
| 5.9 Requirements in building codes, etc. | | | | 3 | 1 | | | | | | | | | | | | | | | | 0.36 | |
| 5.10 Other | | 4 | | | | | | | | | | | | 5 | | | | | | | 0.82 | |

SULZER INFRA

Sulzer Infra Lab AG

# Sulzer Infra Lab AG, Schweiz

| | Organisation: | Interviewed person: |
|---|---|---|
| A1 | Herzog & de Meuron | J. Herzog |
| A2 | Atelier WW | U. Wüst, K. Hangartner |
| A3 | Rolf Läuppi | Rolf Läuppi |
| A4 | Unnamed | N.R. Glockner |
| A5 | Büro Stutz und Bolt | Markus Bolt |
| E1 | Metron Architekturbüro AG | Franco Fregnan |
| E2 | Amstein und Walthert AG | Herr Leibundgut |
| E3 | Grünberg & Partner AG | Hans Meier |
| C1 | Velux Schweiz AG | D. Rossi, S. Zach |
| C2 | Sulzer Infra Ostschweiz AG | Herbert Wyss |
| D1 | Steiner Total Service Contractor | H. Schönholzer |
| D2 | Peikert Contract AG | Alwin Hubmann |
| O1 | Basler Versicherungen | Roland Schmid |
| O2 | Helvetia Patria Immobilienverwaltung | C. Moesch |
| G | Industrielle Betriebe der Stadt Zürich | Dr. M. Lenzlinger |