

Indoor environment and productivity in offices

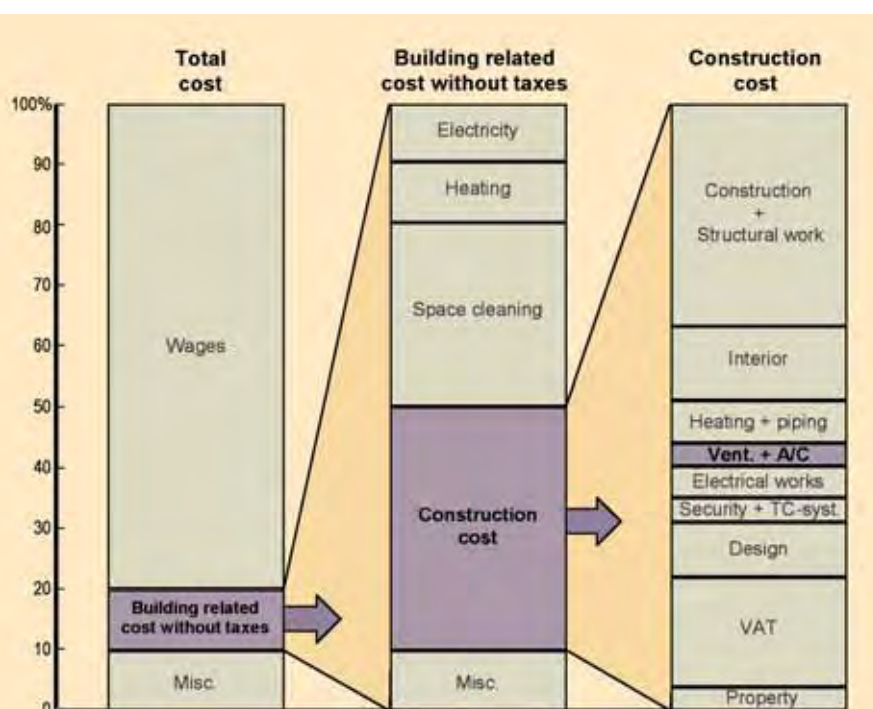
There is increasing evidence that indoor environmental conditions substantially influence health and performance. Macro-economic estimates show that the potential benefits from indoor environmental improvements for the society are high. Some calculations show that the estimated cost of poor indoor environment is higher than energy costs of heating and ventilation of the same buildings. Sample calculations have also shown that many measures to improve indoor air environment are cost-effective when the health and productivity benefits, resulting from an improved indoor climate, are included into the calculations. It is also clear, based on the total cost analysis of any office building, that wages are the most dominant cost item of total cost (Figure 1), and that a value of small improvement in productivity pays easily back the increase in the first cost of HVAC.

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There is an obvious need to develop tools and models so that economic outcomes of health and performance can be integrated in cost benefit calculations with initial, and operation costs. The use of such models would be expected to lead to improved indoor environments, health and productivity. It is important to show to employers and building owners that investment in good indoor environment is beneficial (Figure 2). Most critical in the economic calculations is the link between the indoor environmental factors and productivity. This article presents estimates of some quantitative linkages for cost benefit calculations namely between ventilation rate and sick leave, ventilation rate and performance, perceived air quality and performance, temperature and performance, and temperature and SBS symptoms. This article is based on presentation in the TVVL seminar and publications in the list of references.

BENEFITS FROM THE GOOD INDOOR ENVIRONMENT

The potential benefits of improved IEQ include reduced medical care cost, working days gained due to reduced sick leave, better performance in work, lower turnover of employees, and lower cost of building maintenance due to fewer IEQ complaints. The financial benefits of reduced sick leave are obvious. Performance at work is more complicated to quantify. Three distinct aspects of performance are: quantity (speed), quality (e.g. number of mistakes), and group effect (e.g. how well group works together). The quantity and quality of



An example of the relative significance of wage costs in relation to annual costs for an office building.

- FIGURE 1 -

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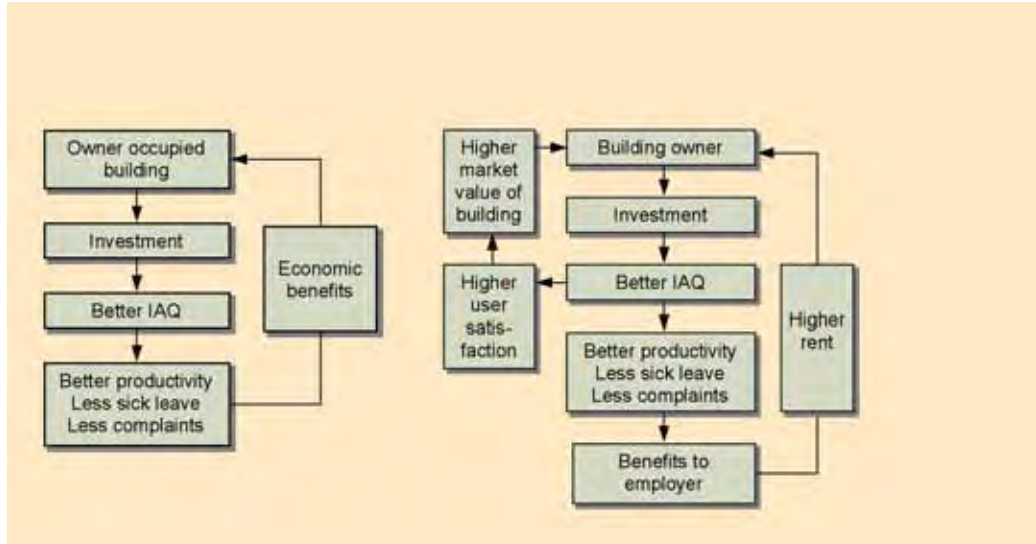
work has been used as a metric in laboratory and field studies. The measurement of work quantity and quality is much easier for repetitive work (e.g. processing of forms). Poor IEQ conditions may also lead to complaints and to communications among employees which may change attitudes about the employer, and, in turn, affect work performance. If IEQ problems are not dealt properly, employee-management conflicts may develop and complicate the problem solving process and reduce productivity; however, the magnitude of this effect is unknown. A reduced job turnover may significantly reduce costs to employers. Reduced number of complaints may also result in reduced work load of facility management personnel. The magnitude of many financial benefits depends on the change in work time (e.g., days at work), or speed, or quality. As a first approximation, financial benefits can be based on employee's salary and related benefits and overhead.

LINKAGES BETWEEN BUILDING FEATURES, IEQ AND HUMAN RESPONSES

To include benefits from the indoor environment in engineering analysis we normally require quantitative estimates of how a building design or operational change influences IEQ conditions and, in turn, quantitative estimates of how these conditions affect health, absence, performance, and other financially-related outcomes. It is not essential to quantify all relations because some data directly link building design (HVAC type) or operation (ventilation rate) to a health or performance outcome (Figure 3). In the following the article summarizes the information on links between temperature, ventilation, SBS-symptoms, health and performance.

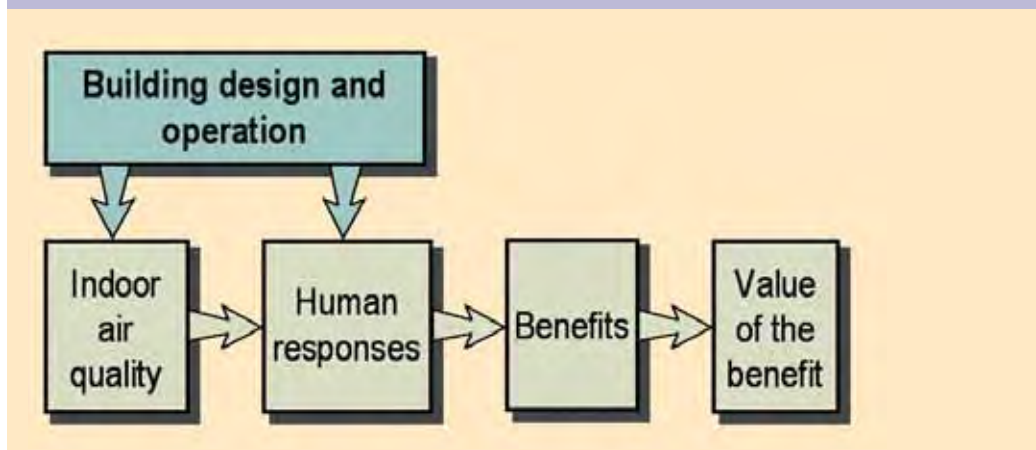
VENTILATION RATES AND SHORT TERM SICK LEAVE

Earlier summaries show that the prevalence of some types of communicable respiratory diseases is higher under conditions with lower ventilation rates. A quantitative relationship between ventilation rate and sick leave was estimated combining published field data and a theoretical model of airborne transmission of respiratory infections [1]. The model (Figure 4) accounts for



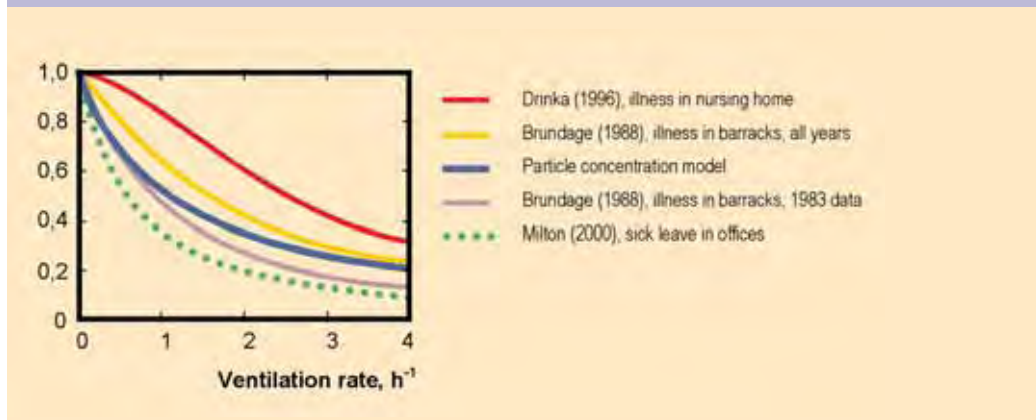
Benefits of improved IEQ are transferred directly to building owner in owner occupied buildings (left) and in leased buildings to building owner via rent and long term value of the building (right).

- FIGURE 2-



Simplified linkage between building, human responses and benefits, [6].

- FIGURE 3-



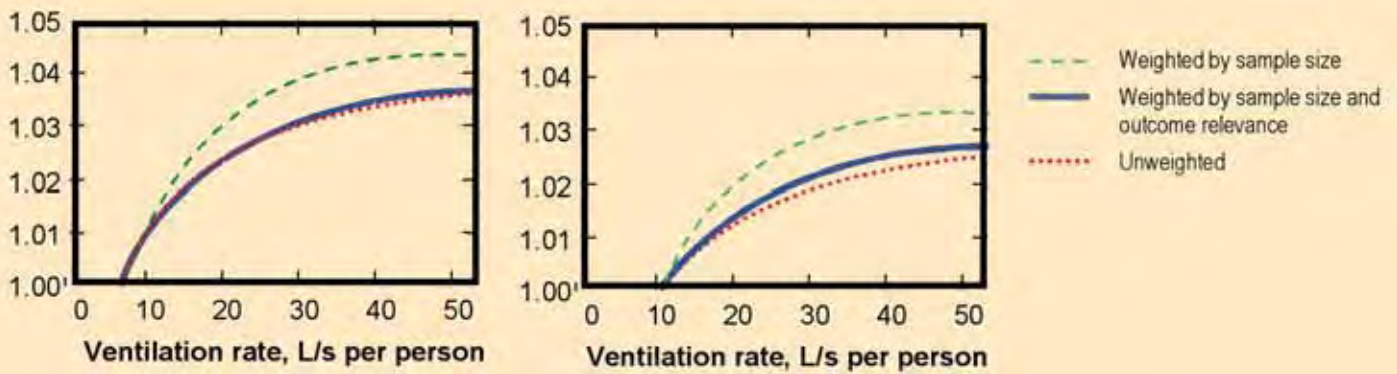
Predicted trends in illness of sick leave versus ventilation rate [1].

- FIGURE 4-

the effects of ventilation, filtration, and particle deposition on airborne concentrations of infectious particles and for the feedback process by which more disease transmission in a building leads to more sick occupants who are sources of infectious particles. The theoretical model is calibrated, i.e., fit to several sets of empirical data, resulting in different curves relating ventilation rates with illness prevalence.

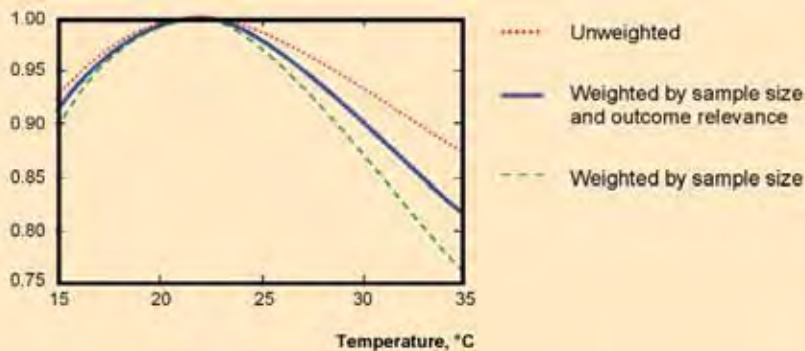
VENTILATION RATES AND PERFORMANCE

Ventilation affects productivity indirectly through its impact on short-term sick leave due to infectious diseases, but also directly. To establish the relation between ventilation rate and performance relevant workplace studies and studies with data collected in controlled laboratory environment were identified [3]. Based on the estimated



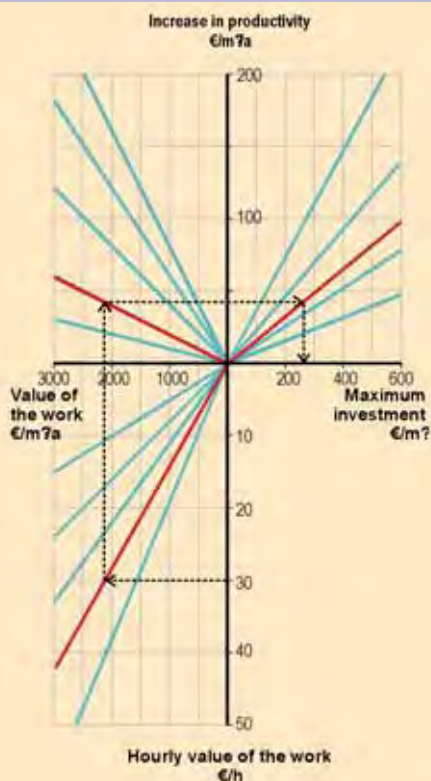
Relative performance in relation to the reference value at 6.5 L/s-person (above) and 10 L/s-person versus average ventilation rate [3].

- FIGURE 5-



Relative performance vs. temperature. Maximum performance is set equal to 1 [4].

- FIGURE 6-



Break-even investment cost (€/m²-office floor area) to improve indoor environment with different value of work (€/m²-office floor area) depending on gained productivity (1, 2, 4, 6, or 8 %), annuity factor of the investment in owner occupied buildings where the building owner gets as an employer all benefits from improved productivity.

- FIGURE 7-

of buildings and indoor environments have been linked to the prevalence of building-related SBS-symptoms experienced by the occupants of the building.

[2] suggest, based on data from a call centre that an average reduction of 7.4 %-points in the prevalence of weekly central nervous symptoms correspond with a 1.1 % increase in productivity. [5]) report a linear relationship between intensity of mean score of neurobehavioral symptoms and average talk time in a call centre. The talk time improved (shortened) 5 % per 10 points change in intensity of symptoms. The intensity of symptoms was measured with an analogous-visual scale from 0 to 100.

CONCLUSIONS

For cost-benefit analyses leading to improved IEQ, health and productivity, it is not sufficient to have information demonstrating a statistically-significant association between an IEQ condition and health or performance, the size of that effect must be estimated quantitatively. This article demonstrates that it is possible, with existing data, to estimate quantitative relationships between ventilation rate and illness-caused absence, and to estimate quantitatively how work performance relates with ventilation rate, air temperature, and SBS-symptoms. These resulting quantitative relationships have a high level of uncertainty; however, use of these relationships may be preferable to the current practice, which ignores health and performance related productivity in decisions about building design or operation. When the relation between indoor environmental parameters and productivity is known the economic analysis can be easily made (Figure 7).

polynomial models, the performance at all ventilation rates relative to the performance at reference ventilation rates of 6.5 L/s-person and 10 L/s-person were calculated and plotted in Figure 5.

TEMPERATURE AND PERFORMANCE

While the effects of temperature on comfort are broadly recognized, the effects on worker productivity have received much less attention. For this linkage existing information on how temperature affects performance was collected so that these effects could be incorporated in cost benefit calculations related to building design and operation [4].

From these data a curve of performance in relation to maximum performance was developed (Figure 6). For example, at the temperature of 30 °C the performance is 90 % of the maximum performance at 21.8 °C, i.e. the reduction in performance is 10 %.

Relative performance as a function of temperature

SBS-SYMPTOMS AND PERFORMANCE

In many prior studies, characteristics

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Berichten

WEINIG LEIDINGWATER-INSTALLATIES IN ORDE

NEN gaat met een commissie aan de slag met het opstellen van een document voor het reinigen en desinfecteren van leidingwaterinstallaties. De wens hiervoor komt vanuit de markt. Op een recent TVVL-congres stelden deskundigen vast dat de leidingwaterinstallaties in hotels, ziekenhuizen, kampeergebouwen en vooral gevangenissen er op legionellagebied 'bar slecht' voor staan. Dit blijkt uit cijfers van de inspectieafdeling van PWN. Ongeveer 10 procent van de gecontroleerde installaties blijkt helemaal in orde zijn. In 2005 (definitieve cijfers over 2006

zijn nog niet bekend) werden 40.000 installaties die vallen onder hoofdstuk IIIc van het Waterleidingbesluit, gecontroleerd op naleving van de specifieke beheersvoorschriften. 1553 installaties werden ook werkelijk fysiek geïnspecteerd. Slechts 160 installaties daarvan waren helemaal in orde. 170 installaties leverden dusdanige risico's op, dat "de dossiers door de Waterleidingbedrijven in handen van het ministerie van VROM zijn gegeven", zoals Theo de Veer van waterleidingbedrijf PWN het tijdens het congres verwoordde.

BEURSPERIKELLEN

Gerennommerde ondernemingen en organisaties uit de internationale branche voor koude- en klimaattechniek hebben enige tijd geleden besloten een nieuwe beurs te starten. Deze vakbeurs met de naam Chillventa zal van 15 tot en met 17 oktober 2008 plaatsvinden in Neurenberg. Chillventa moet de meest prominente internationale vakbeurs worden voor de koude-, klimaattechniek- en ventilatiebranche, zo melden de initiatiefnemers. Het initiatief is een voortvloeisel uit de vastgelopen besprekingen met de organisator van de IKK-vakbeurs. De IKK is al ruim 25 jaar thuisbasis voor vooral de koude- en koeltechnische branche, maar is enkele jaren geleden een weg ingeslagen die geen unanieme steun meer kan vinden bij de deelnemende exposanten. De initiatiefnemers van Chillventa hebben vooral bezwaren tegen de jaarcyclus van de IKK (voorheen om het jaar), het overstappen van Neurenberg naar Hannover in de even



jaren en de aansluiting in de oneven jaren bij de internationale vakbeurs ISH in Frankfurt. Dit levert lagere bezoekersaantallen op en doet afbreuk aan de conceptuele uitstraling van de beurs. Er was bij de IKK-organisatie bovendien geen bereidheid om andere partijen in de branche bij de besluitvorming te betrekken dan de Duitse branchevereniging VDKF, die eigenaar is van de IKK. De nieuwe vakbeurs Chillventa telt inmiddels (april 2007) tweeduizend exposanten, waarmee bijna 60 procent van het beschikbare beursoppervlak is bezet.

MINISYMPOSIUM GEZONDE INSTALLATIES

Op 13 juni 2007 vindt bij de Technische Universiteit Eindhoven de tweede editie van het minisymposium 'Gezonde Gebouwen' plaats. Het symposium wordt georganiseerd door de leerstoel Public Health Engineering for Built Environments. De toepassing van de HACCP benadering op de verschillende groeimarkten (intelligente thuisomgevingen en gezonde binnenmilieus) zal getoetst worden op bruikbaarheid. Installatietechnologie krijgt in de vergrijzende samenleving een steeds

prominentere rol. Vraagstukken als 'hoe kunnen ouderen zoveel mogelijk zelfstandig participeren in de samenleving' en 'hoe houden wij mensen tot op hoge leeftijd vitaal' staan zowel nationaal als internationaal hoog op de politieke agenda. De installatietechnologie biedt in meerdere richtingen oplossingsruimten om deze vraagstukken te beantwoorden. Intelligente Thuisomgevingen (Domotica) en het bieden van een gezond binnenmilieu komen tijdens dit symposium aan bod.