A regulatory framework for indoor environment

Evaluation criteria
Analysis methodology

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With new evaluation criteria for the indoor environment and methodology adapted for analysis of their condition, the new framework provide a basis for creating satisfactory indoor environments with the potential to be made sustainable.

In addition, it provides the conditions to streamline the management work, for example through the identification of buildings where a maintenance service is most beneficial

Content

Definitions

Analysis: Measurement and reporting (of indoor environment properties),
Building physical deficiencies; Building physical deficiencies include the building structure, building envelopes, heating and ventilation systems and other technical systems that affect the indoor environment and/or energy use,
Physical perspective: A perspective that means that the properties of the indoor environment are governed by national norms linked to certain physical indoor environmental factors,
The holistic perspective: A perspective that means that the properties of the indoor environment are governed via a quality definition that includes all perceivable indoor environmental factors,
Physical indoor environmental factors: Collective term for indoor environmental factors of a physical, chemical, biological and electromagnetic nature**,**
Comfort factors: Perceived indoor environmental factors, mainly heat, air, sound and light - the same as **quality factor**s,
Quality: All the combined properties of an object or phenomenon which give it the power to satisfy expressed and implied needs
Quality defect: Deviation from ”setpoint”,
Problem: Expression of an unsatisfactory situation regarding the quality of the indoor environment, quality deficiencies, building physical deficiencies and the like.

ENERGY AND INDOOR ENVIRONMENT

Regulations for energy use

Energy use and energy efficiency are overarching issues in the built environment. Comprehensive, detailed national and international regulations describe how the energy use of buildings should be managed and reported.

The system error

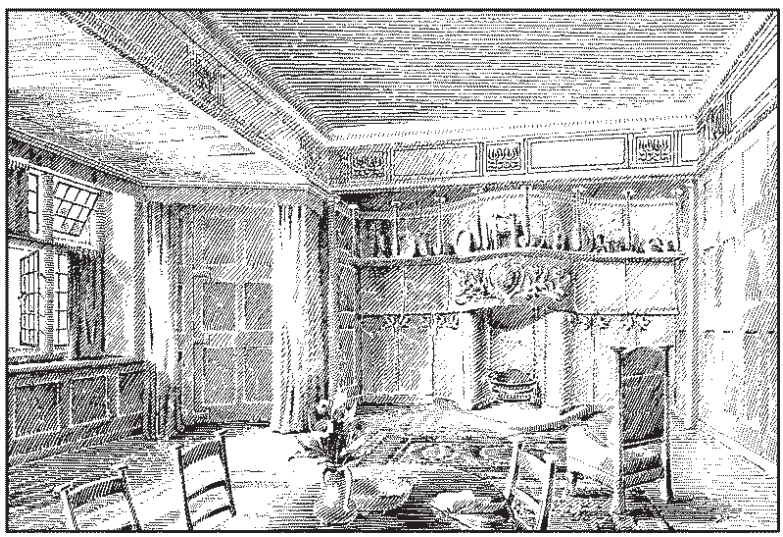
A building is constructed to provide a satisfactory indoor environment for the activity in question – the actual goal is related to the indoor environment and not to energy use.

Setting detailed targets for energy use without giving the indoor environment a corresponding target is a system failure. This has seriously hampered the development of indoor environments with low energy use and high quality (sustainable indoor environments).

Regulations for indoor environment

For a long time the Swedish Indoor Environment Institute has carried out extensive investigations and analyses of the indoor environment in a large number of buildings with various activities. These studies form the basis for the development of a new ”regulatory framework for the indoor environment”.

With evaluation criteria for the indoor environment and adapted methodology to measure and report their condition, it shows a path to good indoor environments with the potential to be made sustainable.



EVALUATION CRITERIA

Evaluation criteria for the indoor environment

The indoor environment's evaluation criteria are quality, quality deficiencies and sustainability.

The quality criterion

Quality definition

The International Quality System Standard defines quality as "all the combined characteristics of an object or phenomenon that give it its ability to satisfy expressed and implied needs".

Applied to the indoor environment, this quality definition means that:

the indoor environment is seen from a holistic perspective (page 7),
the indoor environment users' experiences (experience factors) bear quality.

Divided into heat, air, sound and light

Due to the different functions of the senses, the indoor environment experience is not uniform. It is divided into heat, air, sound and light. For this reason, the quality of the indoor environment cannot be reported with a single overall quality score. Poor heat quality, for example, cannot be compensated for by better air quality.

This means that the quality of the indoor environment is expressed as heat,- air, sound and light quality.

Reported on a quality rating scale

Judging quality as good or bad is simple but unsatisfying. In order to be able to compare the indoor environment in different buildings and premises, the quality of comfort factors (quality factors) is classified and transformed into quality ratings in a numerical rating scale from +3 (very good) to -2 (unacceptable).

The quality deficiencies criterion

Quality deficiency definition

Quality deficiency is defined as deviation from "set point".

Reported as deficiency value

Quality deficiencies are reported as quality deficiency value for each comfort factor in a numerical scale from 0 to 100. Those values are transformed to an overall quality deficiency index, QDI, on a scale from A (no quality deficiencies) to G (unacceptable quality deficiency situation). Many quality deficiencies result in poor QDI.

The sustainability criterion

Sustainability definition

Sustainability is a relationship between quality, quality deficiencies index and energy performance. It is reported with a sustainability index, SBI, on a scale from A to G. Index SBI A and SBI B represent a sustainable indoor environment.

PERSPECTIVES

The meaning of perspectives

The indoor environment can be seen from two perspectives – the physical perspective and the holistic perspective.

The Physical Perspective

The physical perspective basically means that the properties of the indoor environment are governed via national standards that are linked to a limited number of physical indoor environmental factors.

Other physical indoor environmental factors are not standardized, which can lead to disagreement about the indoor environment situation – is the indoor environment acceptable or not?

Form of control

Verification that standardised physical indoor environmental factors meet applicable standards is carried out using adapted methodology.

Cost structure

The cost structure of the physical perspective mainly includes the operating and maintenance costs that are required to maintain the requirements for standardized physical indoor environmental factors.

As a rule, it is not profitable to improve the quality of the indoor environment beyond that provided by compliance with the national standards.

The Holistic Perspective

The holistic perspective means that experiences (experience factors) such as cold, hot, draughts, smells are quality-bearing.

The holistic perspective differs from the physical perspective in that the properties of the indoor environment are governed via a quality definition that includes all perceivable indoor environmental factors.

Form of control

The quality of the indoor environment is monitored through questionnaires.

Cost structure

In addition to the costs of the physical perspective, the holistic perspective also includes indoor environment-related ”social” costs, which can include ill- health, impaired performance and reduced well-being for indoor environment users.

Poor indoor environment quality can, in the holistic perspective, cause costs and problems with a completely different dimension than what applies to the building physics perspective.

A Cost scenario, page 8, deals with this issue.

COST SCENARIO

Summary

The perspectives have completely different cost figures. To illustrate this fact, a fictitious scenario is described here. A building with administrative activities and normal salary level for administrative work is made more energy efficient by a marginal, permanent reduction of the indoor temperature.

Result

Energy use

Reported as present value over a ten-year period with an interest rate factor of 2% and energy cost of SEK 2/kWh, improved energy efficiency gives a profit of approximately SEK 25 thousand per workplace.

Performance

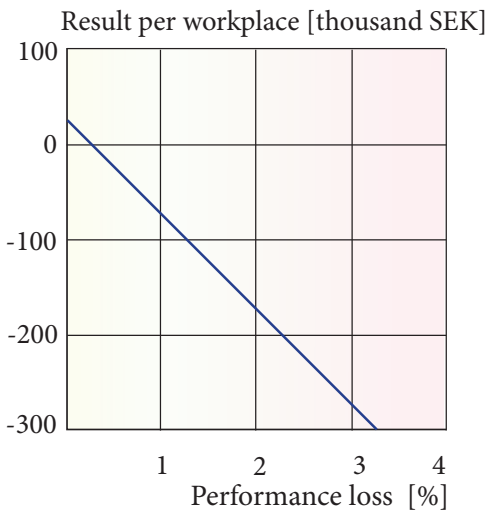
Reported as present value over a ten-year period with an interest rate factor of 2%, the deteriorating of the employees performance, due to the reduction in indoor temperature, results in a cost of approximately SEK 180 thousand per workplace.

Assessment from a physical perspective

If the improved energy efficiency is assessed from a physical perspective, it gives a profit of about SEK 25 thousand per workplace. The measure is profitable.

Assessment from a holistic assessment

If the improved energy efficiency is assessed from a holstic perspective it results in a loss of approximately SEK 180 thousand per workplace. The measure is not profitable.



INDOOR ENVIRONMENT CORRELATION

Definition

Indoor environment correlation is the interface between experiences (experience factors) and physical indoor environmental factors.

The table to the right shows, in a somewhat simplified form, the physical indoor environmental factors that affect the experience of heat, air, sound and light.

	Experience (factors)	Physical factors
HEAT	Heat/cool	Operative temperature Air velocity Relative humidity (RH) Temperature asymmetry Sun radiation
	Variation heat/cool	Operative temperature Air velocity Relative humidity (RH) Solar radiation
	Draught	Air velocity Air temperature
AIR	Smell	Gascontent/type Particle content/type
	Suffocating	Temperature Particle- and CO_2 content Relative humidity (RH)
	Dry	Relative humidity (RH)
	Dusty	Relative humidity (RH) Particle content/type
SOUND	Appliances noise	Sound pressure dBA/dBC
	Ventilation sound	Sound pressure dBA/dBC
	Aktivity noise	Sound pressure dBA/dBC Reverberation time
LIGHT	Brightness	Light level
	Brightness difference	Luminance Contrast Shadows Reflex Glaring
	Incidence of light	Light direction Light distribution
	Colour experience	Light colour

ANALYSIS METHODOLOGY

Background

Identifying indoor environmental problems with conventional inspection is too time-consuming and costly to be used other than in special cases.

There is a great need for an to today's conditions adapted analysis methodology that with relatively simple means and at low cost can clarify the properties of the indoor environment and the need for action. The analysis methodology created by the Swedish Indoor Environment Institute meet these requirements

Usage and Content

The analysis case of the analysis methodology is used to describe the state of the evaluation criteria and the need for action. The methodology mainly consists of:

- a specialised survey procedure;
- methodology for identifying building physical deficiencies,
- methodology for selective inspection and possible measurement of physical indoor environmental factors,
- a computerised evaluation system.

Survey procedure

The survey procedure is based on a uniform questionnaire integrated into the system. It is sent to the indoor environment users in the building in question (the target group) to be answered.

Building Physical Deficiencies

As a rule, building physical deficiencies* are identified through the survey results. If it proves difficult to use this route for identification, a selective inspection is carried out instead.

Selective inspection

Selective inspection is based on the "Memorandum of Inspection". It is a guide for the inspector that shows what the inspection should focus on.

In some cases, a selective inspection may need to be supplemented with measurements of the condition of physical indoor environmental factors. The inspector determines the extent of the measurements and the methodology to be used.

In principle, the measurement procedure can include all relevant physical indoor environmental factors such as temperature, draught, humidity, CO_2, TVOC, particle content. magnetic fields etc.

Instructions

There are separate instructions for the survey procedure, selective inspection, measurement and identification of building physical deficiencies*.

*Includes the building structure, building envelope, heating and ventilation systems and other technical systems that affect the indoor environment and/or energy use.

The description of the measures provides information on the measures that should be taken to eliminate or limit building physical deficiencies. The description of the measures is based on the results of the survey procedure and any inspection-measurement carried out.

Technology or information related?

The first step is to determine what is related to building physical deficiencies and what is information-related.

Three types of action

Measures concerning building physical deficiencies are divided into three types in terms of time requirements and complexity:

type 1: Obviously necessary action that can be carried out, e.g. during inspection (time <30 min),
type 2: Clearly necessary action that can be carried out within a limited period of time (month),
Type 3: Comprehensive measure that should be designed and coordinated with other measures;

Type 1 and Type 2 measures can, as a rule, be carried out without a separate cost estimate. Type 3 measures cost to much to clarify whether and how they can be implemented.

Information-related problems

Information-related problems are addressed with information and/or training.

Limit the stakes or not?

Can existing problems be satisfactorily remedied or should they only be limited?

General proposals for action

General proposals for action for different objects are shown in the table.

Problemoblekt	Measure
	Clean
Contaminated surfaces and building components	Decontaminate, reconditionera
Draft Insolation Sources of pollution Unnecessary loads	Limit-Eliminate
Operation control Building Parts Technical components	Adjust - Repair
Workplace (location, design) Operating times Lamps	Change

ANALYSIS CASES

Analysis cases

The analysis methodology has been adapted for three analysis cases – quality analysis, quality deficiency analysis and sustainability analysis. The results are used as final results or as a basis for identifying building physical defects,

Quality Analysis

A quality analysis is presented with the comfort factors' quality ratings on a numerical five-point scale from +3 to -2. The analysis case is used to:

- demonstrate the quality of the indoor environment;
- examine how a certain measure, e.g. energy efficiency or a possible permanent limitation of the energy supply, affects the quality rating of the comfort factors

Scope of the report

- Short description
- quality rating for the respective comfort factor,
- the views of indoor environment users;
- PM for inspection.

Quality deficiency analysis

A quality deficiency analysis is presented with a quality deficiency value for each comfort factor and an overall quality deficiency index on a seven-point scale from A to G. It provides information about which sub-factors (comfort factors building stones) within each comfort factor have the largest proportion of quality deficiencies of type 2 (important) and type 3 (serious). The analysis case is used to provide a clear and at the same time detailed picture of the quality deficiency situation.

Scope of the report

- short description,
- quality deficiency value for quality defects type 2 and type 3 within the respective comfort factor,
- Quality Deficiency Index,
- Memorandum of Inspection.

Sustainability analysis

A sustainability analysis is presented with a sustainability index on a seven-point scale that goes from A to G. The analysis case is used to clarify whether the indoor environment is sustainable or not and to show the need for action for the indoor environment that is not sustainable.

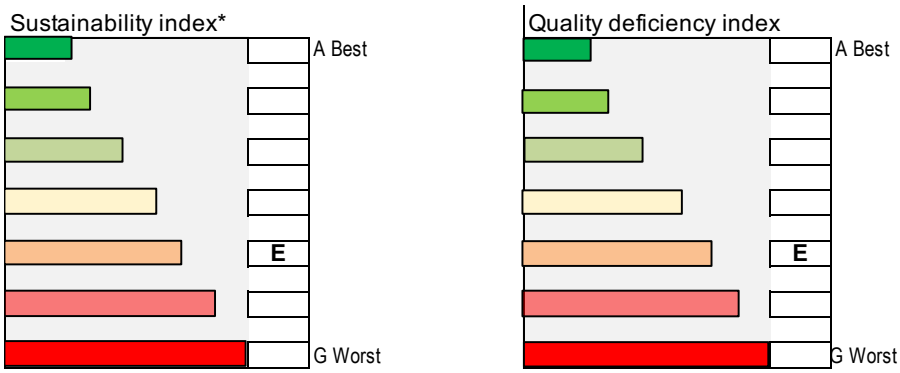
Scope of the report

- description of the results;
- the quality rating of the comfort factors;
- Quality Deficiency Index;
- Sustainability index;
- specific energy consumption (energy performance);
- the presence of allergies and any perceived health effects of the indoor environment (if necessary)

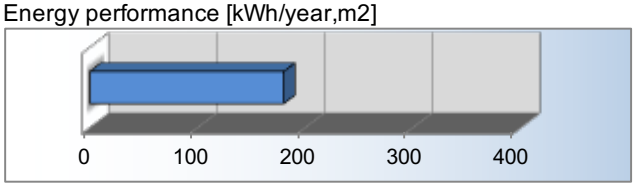
The results of a sustainability analysis, grafic form, is shown on page 13.

SUSTAINABILITY ANALYSIC– Grafic form

Building Sunflower

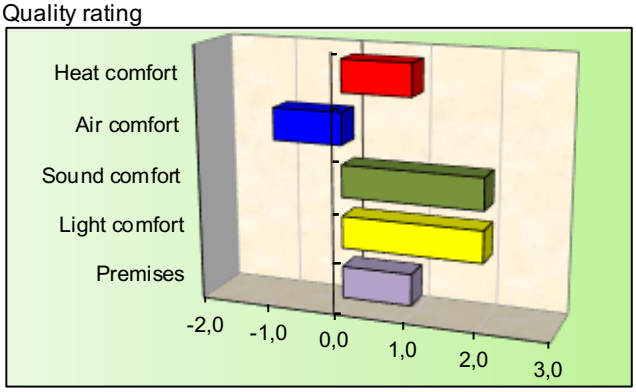


Energy performance [kWh/year,m2]



180	Low value good

Quality rating



Reference	
3	Very good
2	Good
1	Acceptable
-1	Not acceptable
-2	Unacceptable

The graph shows the results of a sustainability analysis. The Quality Deficiency Index and the Sustainability Index are unsatisfying. The reason for this is that air comfort is unsatisfactory and that other comfort factors, except light comfort, do not have a good enough quality rating. The relatively high energy performance value of 180 kWh/year,m2 also contributes to an unsatisfactory sustainability index.

Comments on the analysis methodology

The analysis methodology makes it possible to analyze and report the state of the indoor environment quality at a uniquely low cost.

It clarifies the causes of existing problems and what measures can be taken to eliminate or limit them.

Problems are discovered before they ”grow” and become difficult to manage.

Management work can be simplified and made more efficient, for example, by allocating existing resources to buildings with the greatest need for action.

Appendix 1. Basis for analysis

1. Quality analysis and Quality deficiency analysis

To perform quality analysis or quality deficiency analysis, the following building data is needed

- name or designation,
- street address (not mandatory),
- postal code (not mandatory),
- place,
- number of operational staff normally present in the building (for schools staff and teachers only).

2. Sustainability analysis

For sustainability analysis, the following additional information is required in addition to those listed in point 1.

Building

- building name,
- activity,
- built year,
- area m^2,
- number of dwellings (residential buildings),
- number of floors,
- window type.

Activity

- main activity (category),
- activity B,
- heat source, head,
- heat source 2,
- heat distribution,
- comfort cooling.

Ventilation

- form of ventilation,
- heat recovery.

Energy

- specific. energy consumption [kwh/m^2,year],
- energy efficiency performed or not,
- location of the building.

There are special forms that make it easy to register the above-mentioned information.