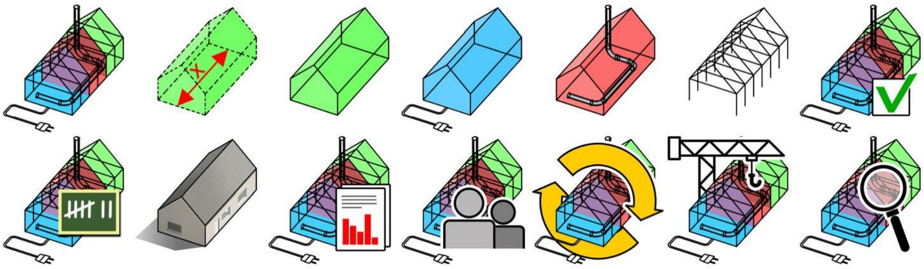

COBIM

Common BIM Requirements 2012

v 1.0

Series 9

Use of models in MEP analyses

Volume 9 compiled by Olof Granlund Oy

Tero Järvinen, Tuomas Laine

Foreword

The publication series "CommonBIM Requirements 2012" is the result of a broad-based development project entitled *COBIM*. The need for these requirements arises from the rapidly growing use of building information modeling in the construction industry. During all phases of a construction project, the parties to the project have a need to define more precisely than before what is being modeled and how the modeling is done. "Common BIM Requirements 2012" is based on the previous instructions of the owner organizations and the user experiences derived from them, along with the thorough experience the writers of the instructions possess on model-based operations.

The parties to the project are: **Funding providers:** Aitta Oy, Larkas & Laine Architects Ltd, buildingSMART Finland, City of Espoo Technical and Environment Services, Future CAD Oy, City of Helsinki Housing Production Office, City of Helsinki Premises Centre, University of Helsinki, Helsingin Yliopistokiinteistöt Oy, HUS Kiinteistöt Oy, HUS Premises Centre, ISS Palvelut Oy, City of Kuopio Premises Centre, Lemminkäinen Talo Oy, Micro Aided Design Ltd. (M.A.D.), NCC companies, Sebicon Oy, Senate Properties, Skanska Oy, SRV Group Plc, Sweco PM Oy, City of Tampere, City of Vantaa Premises Centre, Ministry of the Environment. **Authors:** Finnmap Consulting Oy, Gravicon Oy, Olof Granlund Oy, Lemminkäinen Talo Oy, NCC companies, Pöyry CM Oy, Skanska Oyj/VTT Technical Research Centre of Finland, Solibri, Inc., SRV Rakennus Oy, Tietoa Finland Oy. **Management:** The Building Information Foundation RTS.

The requirements were approved by an executive group consisting of parties to the project. The executive group acted as committee TK 320 of the Building Information Foundation RTS, and as such, participated actively in developing the content of the requirements and in asking for comments from the members of the executive group and interest groups.

Parties to the © COBIM project.

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1 Main objectives of building information modeling

Property and construction modeling aims to support a design and construction lifecycle process that is of high quality, efficient, safe and in compliance with sustainable development. Building information models are utilized throughout the building's life cycle, starting from initial design and continuing even during use and facility management (FM) after the construction project has concluded.

Building information models enable the following, for example:

- Provision of support to the investment decisions by comparing the functionality, scope and costs of the solutions.
- Energy, environment and lifecycle analyses for the purpose of comparing solutions, design and objectives of facility management follow-up.
- Design visualization and analysis of construction feasibility.
- Enhancement of quality-assurance and data exchange and making the design process more effective.
- Utilization of building project data during use and facility management activities.

To make modeling successful, project-specific priorities and objectives must be set for models and model utilization. Project-specific requirements will be defined and documented on the basis of the objectives and general requirements set in this publication series.

General objectives of building information modeling include, for example, the following:

- To provide support for the project's decision-making processes.
- To have the parties commit to the project objectives by means of using the building information model.
- To visualize design solutions.
- To assist in design and the coordination of designs
- To increase and secure the quality of the building process and the final product.
- To make the processes during construction more effective.
- To improve safety during construction and throughout the building's lifecycle.
- To support the cost and life-cycle analyses of the project.
- To support the transfer of project data into data management during operation.

"Common BIM Requirements 2012" covers targets for new construction and renovation, as well as the use and facility management of buildings. The minimum requirements for modeling and the information content of models are included in the modeling requirements. The minimum requirements are intended to be observed in all construction projects where the use of these requirements is advantageous. Besides the minimum requirements, additional requirements can be presented on a case-specific basis. Modeling requirements and content must be presented in all design contracts in a binding and consistent manner.

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The publication series “Common BIM Requirements 2012” consists of the following documents:

1. General part
2. Modeling of the starting situation
3. Architectural design
4. MEP design
5. Structural design
6. Quality assurance
7. Quantity take-off
8. Use of models for visualization
9. Use of models in MEP analyses
10. Energy analysis
11. Management of a BIM project
12. Use of models in facility management
13. Use of models in construction
14. Use of models in building supervision

In addition to the requirements in his or her field, each party to a building information modeling project must be acquainted at a minimum with the general part (Series 1) and the principles of quality assurance (Series 6). The person in charge of the project or the project's data management must have comprehensive command of the principles of building information modeling requirements.

2 Introduction

This document addresses the analyses made by the MEP designer on the basis of the available building information models. The document does not take a stand on the tools used for performing the analyses.

The analyses focus on the building, individual type or sample spaces or the MEP system..

3 MEP analyses

Many of the solutions prepared by other designers, such as the shape of the building chosen by the architect or the choice of structures made by the structural designer,have direct lifecycle effects in the MEP systems, for example, increased energy consumption.

However, the possible errors or uneconomical solutions cannot be corrected on the basis of the MEP system alone at the stage when the spatial and structural solutions have already been decided. On the contrary, in that case special solutions will often be required for the MEP systems as well, which will increase the costs even further.

For this reason, it is important that the MEP designer is involved in the design process from the beginning of the project.

MEP analyses provide information about the energy efficiency and life-cycle costs of the design solution, among other things.The use of BIMs makes the preparation of MEP analyses more effective. Analyses can be performed even on the basis of very simple and preliminary BIMs. This will generate considerable added value in terms of the decision-making inthe design process.

At the early stage of the design, analysis focus on the comparison of alternatives, and at later stages on the assessment of the design solution's conformance to the objectives.

3.1 Energy- and comfort simulations

Instructions for energy- and comfort simulation can be found in Series 10, "*Energy analysis*".

3.2 CFD simulation

Indoor air conditions are significantly affected by the combined effect of incoming air showers and different loads and structures.

Computational fluid dynamics (CFD) refers to the analysis of the airflow and distribution of heat within a single space. It provides detailed information on the temperature and air flow conditions. This type of simulation is normally used for analyzing special constructions, such as high or otherwise demanding spaces and large public spaces.

CFD simulation utilizes the architects IFC model as source data. If a MEP system model is available, it can be utilized for preparing CFD simulation.

The goal of CFD simulation is to predict indoor airflows and produce computational data to facilitate making system selections.

CFD simulations enable the determination of temperature conditions, comfort level, air quality, speed, humidity, carbon dioxide level, age and other factors affecting indoor air conditions in a space by means of visualization using images and animations.

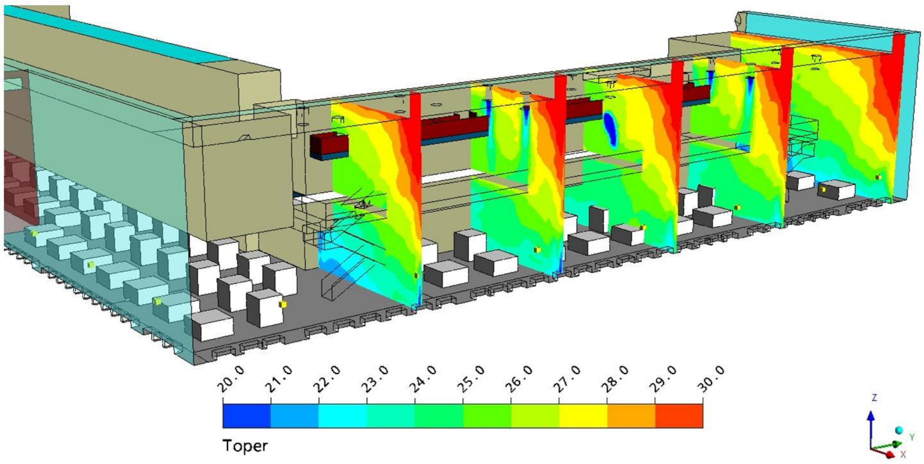

Figure 3.2.1: Temperature distribution in a glassed entrance hall space.

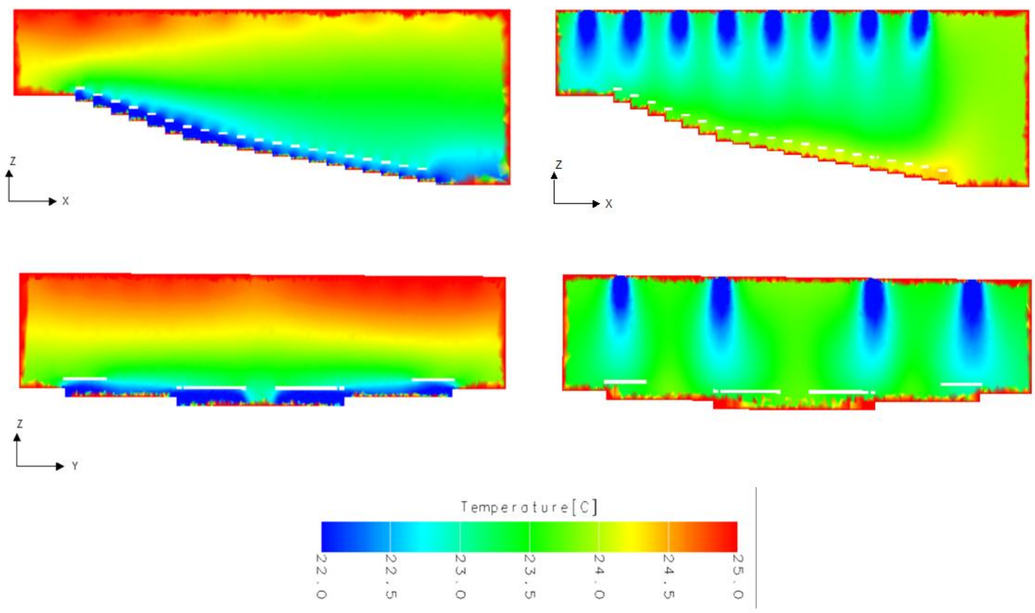

Figure 3.2.2: Temperature distribution in an auditorium when comparing two different ways of air distribution (displacement ventilation / mixing ventilation)

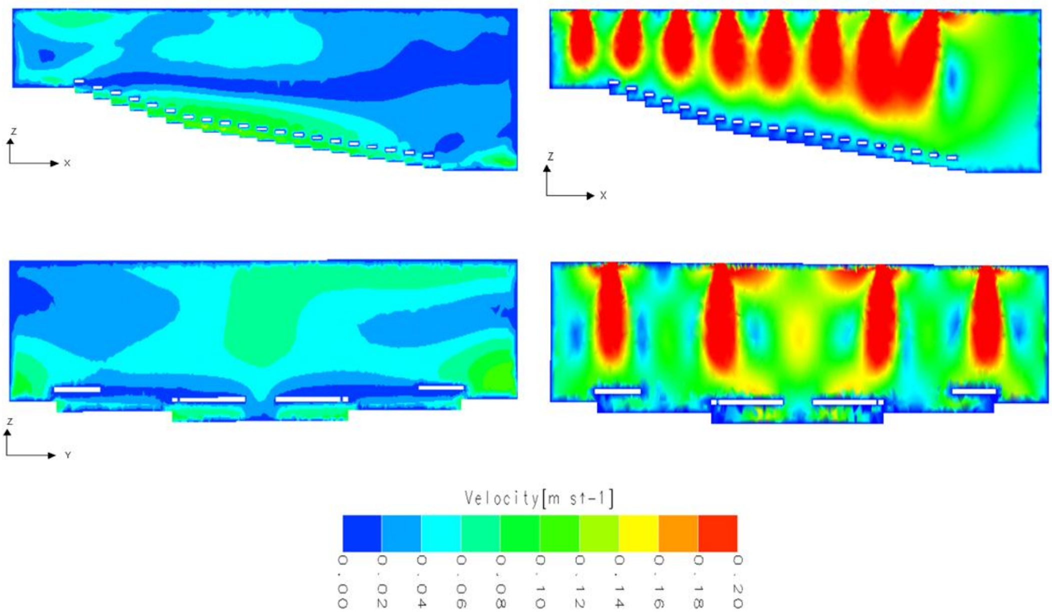

Figure 3.2.3: Air velocity using two different methods of air distribution (displacement air / mixing air)

Chapter 3.2 References to the task allocation list (Scope of work, MEP-design):

D 0 Preliminary design, discretionary tasks:
Item D 2.11, Computational fluid dynamics (CFD), level c (MEP)

E Design Development, discretionary tasks:
Item D 3.7, Computational fluid dynamics (CFD), level c (MEP)

Project information card:

Item 2.4.5 Condition / indoor air, level c

3.3 Analysis of MEP life-cycle costs

Usually, the most important decisions concerning the building's useful life, adaptability or energy economy are made at the project or preliminary design stage. At that time, the building's size, shape, location of spaces, major structural decisions and quality level of indoor conditions are determined.

At later design stages, the decisions made at the project design stage limit solution opportunities when, for example, MEP system solutions are compared.

Frequently, decisions concerning, for example, energy consumption and ecological efficiency characteristics, are based on assumptions, empirical assessments and statistical identification numbers. In many cases, these data do not have a direct link to the planned construction and its special characteristics.

When the sketches drafted by the architect are compared by means of reliable life-cycle calculations at the earliest possible design stage, both design and implementation can be guided toward solutions that are more advantageous in terms of the building's life cycle than what is presently the case.

In life-cycle design, the building is modeled on the basis of the sketches at the project or sketch design stage. The first estimate of heat and electrical energy consumption is calculated on the basis of the building's spatial program and information concerning expected duration of use. Energy simulations and comfort simulations are used to compare different building shapes, effects of the size of the windows and the window solutions that were used, quality levels of indoor air, etc.

Simulations of energy consumption and indoor air conditions that take the building's special characteristics into consideration play a central role in life-cycle examinations.

The energy costs incurred in a building that was designed and implemented to be cost- and eco-effective are optimal, and indoor air meets the building's needs.

When life-cycle cost examinations are performed thoroughly and at the early stage of design, comparisons of indoor air quality levels and their costs – achievable through different system solutions – during the building's life cycle, can be presented to support decision-making.

Typically, comparisons are made with regard to the following sub-areas:

- the size and properties of windows, sun protections
- alternative structural solutions, thickness of insulations
- a solution in principle concerning ventilation and cooling (based on airflow; cooling beams, fan coil units, etc.
- heat recovery ventilation solution (which recovery method is selected)
- solutions for directing ventilation (presence-directed or carbon-dioxide-directed ventilation according to need, etc.)
- lighting solutions (lighting fixtures, lamp types, direction according to need, etc.)
- utilization of daylight in lighting
- realization of conversion flexibility by means of different structural and MEP solutions

Frequently, a system part that has been delimited is observed to enable comparison of different alternatives, or the effect of a certain structural solution (e.g. external walls, windows) on the building is viewed throughout the building's entire life cycle.

<u>Chapter 3.3 References to the task allocation list (Scope of work, MEP-design):</u>

E Design Development, discretionary tasks:
Item E 3.9, Life-cycle cost accounting

Project information card:

Item 2.4.8 Life-cycle costs (LCC)

3.4 Environmental impact analysis

The environmental impact is analyzed on the basis of the architect's Building Element BIM and the MEP System BIM. The analysis of environmental impacts can be used for assessing the energy consumption, consumption of raw material, emissions of the building and service life of building elements. The results obtained will illustrate these characteristics of the design solution. The quantity information contained in the MEP and Building Element BIMs can be utilized for the analysis.

Since the share of the building's energy consumption is roughly 80% of its entire environmental impact, even energy simulation alone is often sufficient to depict the environmental impact. It should be noted, however, that as energy consumption decreases, the relative significance of environmental impacts bound to the structural frame and MEP systems increase accordingly.

Chapter 3.4 references to the task allocation list (Scope of work, MEP-design):

E Design Development, discretionary tasks:
Item E 3.10, Environmental impacts

Project information card:

Item 2.4.10 Environmental impacts (LCA)

3.5 Technical visualization images

Combining the MEP BIMs with the architect's or structural designer's BIM makes it possible to estimate how the MEP terminal devices (mixers, sockets, switches, radiators, ventilation terminal devices, lighting fixtures, etc.) adjust to the architecture of the building in projects where this is of critical importance.

The examination can be carried out through images or animations. The examination can also be performed using well-developed merged-model viewing software that, in part, takes materials into account.

In laboratory and hospital settings in particular, technical visualization images make the placement and appearance of MEP equipment easy for the user to observe and understand.

The purpose of technical visualization images is not to examine the lighting or use of colors in a space, but to draw attention to the technical details.

The distribution of visualization tasks between the architect and the MEP designer, and the accuracy of source data required for it, must be agreed in the design agreements.

Figure 3.5.1: Visualization image of a laboratory space (renovation project)

Figure 3.5.2: Visualization image of washroom piping systems

Chapter 3.5 References to the task allocation list (Scope of work, MEP-design):

Project information card:

Item 2.4.1 Visualization materials produced by the designer

3.6 Lighting calculation and visualization

Lighting calculation is used for calculating and presenting in numerical form the luminosity provided by the lighting fixtures in the room and the glare index in the space and on the various surfaces of the space. The architect's BIM and the electrical designer's System BIM are used for the lighting calculation, if the software has that capacity.

Since a specific aim is often to study the lighting conditions on locations such as a desktop surface, the Architectural BIM must also contain the furniture in the room to make the calculation possible. The calculation can be performed on a sample space or all necessary spaces.

Lighting calculation requires a considerably smaller effort than lighting simulation, but the results obtained are less illustrative.

Lighting visualization is used for illustrating the effects of selected lighting fixtures on the character of the interiors and the lighting of the room. In addition, a rough examination of the effects of daylight and glare can be conducted.

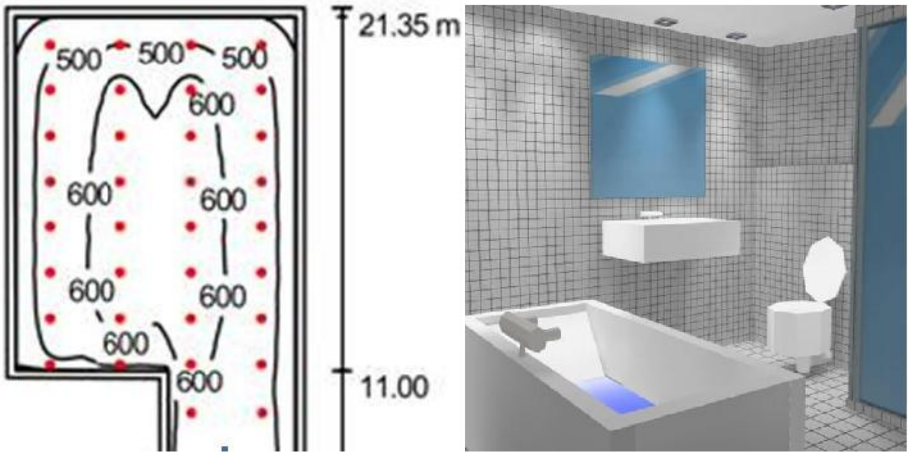

Figure 3.6.1: Lighting calculation and -visualization

<u>Chapter 3.6 References to the task allocation list (Scope of work, MEP-design):</u>

D 0 Preliminary design, basic tasks:
Item D 3.8, Lighting calculation

D 0 Preliminary design, discretionary tasks:
Item D 2.13, Lighting visualization

E Design Development, discretionary tasks:
Item D 3.6, Lighting visualization

Project information card:

Item 2.4.6 Lighting, level a and b

3.7 Lighting simulation

The software used for lighting simulation must have the capacity to calculate the actual lighting from several lighting sources and reflections induced by surface materials.

Information concerning the surface materials and their reflection characteristics, and the fixtures in the spaces, is needed for the simulation. The resulting views resemble photographic images and depict actual conditions quite well; a crucial difference compared to visualization is that lighting levels are also shown on different surfaces. Some software programs enable the examination of the ergonomic problems caused by disturbing shine and glare.

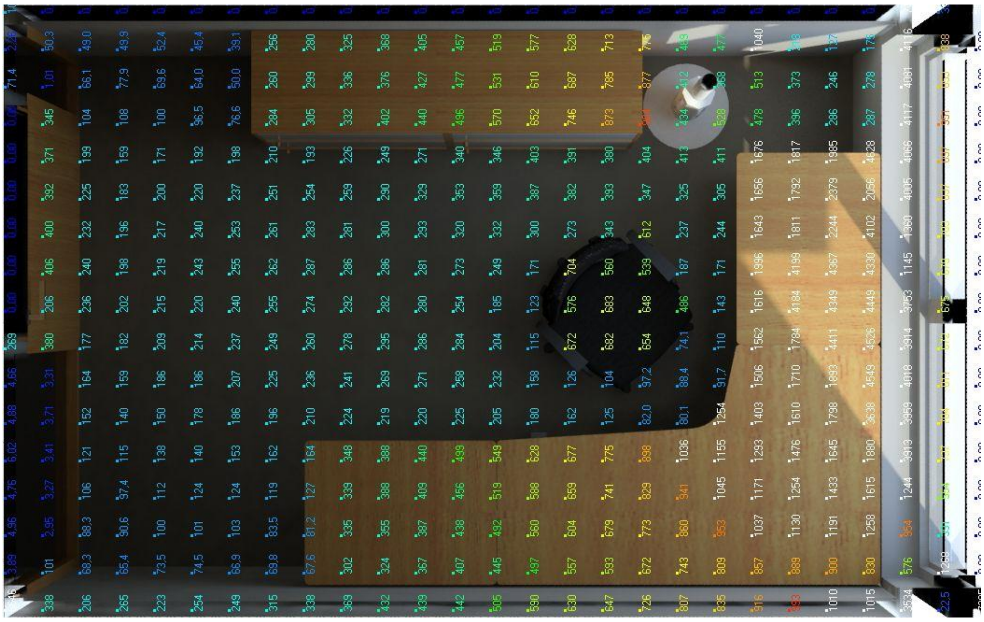

Figure 3.7.1: Illumination of an office space in natural light. Lux quantities are shown numerically.

The architect's BIM and the electrical designer's System BIM are used for the lighting simulation. When the intention is to examine the final impression or lighting conditions in a work space, for example, the architect's model must also include the furniture in the space. To achieve reliable lighting simulation, it is often necessary to modify or remodel the 3D model of the space or building to correspond to the requirements of the simulation programs. However, the person carrying out the simulation will need the architect's and electrical designer's models to conceptualize the contents of the space.

Lighting simulation is usually done on agreed-upon sample spaces or the building's façade lighting.

Figure 3.7.2: Simulation of a building's façade lighting.

Simulation can also be used to examine the behavior of daylight in different spaces.

Figure 3.7.3: Comparison of artificial lighting and daylight by means of a lighting shelf.

The lighting simulation model can also be used to create animations, when necessary.

The level of simulation, accuracy of the necessary source data, and distribution of tasks between the architect, lighting designer and the author of the simulation must be agreed in the design agreements.

<u>Chapter 3.7 References to the task allocation list (Scope of work, MEP-design):</u>

D 0 Preliminary design, discretionary tasks:
Item D 2.14, Lighting visualization, level c

E Design Development, discretionary tasks:
Item D 3.6, Lighting visualization, level c

Project information card:

Item 2.4.6 Lighting, level c

3.8 MEP system analyses

The MEP System BIM can be utilized for conducting analyses of the functions of many different systems; typically, this can be done directly by using the MEP system modeling software. To do so, the model must contain sufficiently dynamic data describing the networks' function.

MEP system analyses can be used to verify the economic function of the networks over their life-cycle before the construction stage, and the realization of the design values in conformance with the requirement model.

A MEP System BIM that is calculated correctly in terms of flow and pressure technology establishes the conditions needed for controlling the networks. Appropriate control of the networks enables the realization of the spaces' conformance to the technical requirements (air quantity, cooling and heating capacity, etc.).

The required MEP system analyses are presented in Series 4, "*MEP design*".

3.9 Conducting the analyses and presenting the results

All source data must be derived from the same design version, and any conflicts in them must have been inspected and resolved. The existence of the necessary source data is verified before undertaking simulation and the source data or default values used are documented to ensure they are available when the results are examined. In addition, all analysis results must be attached to the file package that was used, because alone or in connection with other material they no longer provide accurate information regarding the design.

The results must be modified to be illustrative in shape so that a person who is not a MEP expert or an expert in construction can understand them.

The amount of data should be limited to include that which is essential. In presenting the results, an effort should be made to utilize tables and diagrams, if the analysis software program does not produce direct visualizations.

The models that form the basis for the analysis can also be utilized in visualizing the results. The spatial model can be used to visualize the results of the simulation of ambient conditions; for example, spaces that do not meet the objective can be colored red. Colors can also be used to simulate building elements which the analysis results have indicated are critical.

When performing the first analyss, it is a good idea to present different solution alternatives to facilitate making further decisions. When one alternative has been chosen from among many, the chosen alternative can be further refined to ensure its functionality as a starting point for further design work.

Visualization of analysis results is significant because they help all project participants to understand the results of the analyses more quickly.