INFORMATION DELIVERY MANUALS TO FACILITATE IT SUPPORTED ENERGY ANALYSIS

Thomas Fænø Mondrup, PhD Student, tfmo@byg.dtu.dk
Jan Karlshøj, Associate Professor, jak@byg.dtu.dk
Flemming Vestergaard, Associate Professor, fv@byg.dtu.dk
Department of Civil Engineering, Technical University of Denmark (DTU), Kgs. Lyngby, Demnark

ABSTRACT

In response to continuing Building Information Modeling (BIM) progress, building performance simulation tools such as IESVE are being utilized to explore construction projects and influence design decisions with increasing frequency. To maximize the potential of these tools, a specification of information exchange and digital workflows is required. This paper presents the preliminary findings of an ongoing study aimed at developing an Information Delivery Manual (IDM) for IT supported energy analysis at concept design phase. The IDM development is based on: (1) a review of current approaches (2) a qualitative survey of professionals within the industry, and (3) mapping of selected energy simulation tools. Specifically, this study focuses on the issue of implementing standardized IDMs across national borders (in this study Denmark and Sweden.

Keywords: BIM, IT supported energy analysis, IDM, energy efficiency

1. INTRODUCTION

1.1 Interregional Framework

The framework of this study is directed toward the Interreg IV A Öresund Programme "Integration of Sustainable Construction Processes – by the use of Information and Communication Technology" (Karlshoej 2009). The purpose of the Interreg IV A Öresund Programme is to enhance the market and the collaboration in the construction sector across the Öresund Region (transnational region centered on the cities of Copenhagen and Malmö), and also to enhance digital collaboration and implementation of Building Information Modeling (BIM). In principle, the Danish and Swedish construction sectors have many similarities. However, if actors are to collaborate across the Öresund Region, regional network and common *translators* of national systems are needed.

1.2 Background to Study

Buildings are responsible for some 40% of the total energy consumption in the European Union (EPBD 2010). Consequently, there is a need to improve the energy efficiency and wider sustainability performance in the built environment. Such improvements require optimization of the building design and clever optimization of all energy flows within and through the building. Here IT supported building performance simulations and energy analysis (that is, IT supported energy analysis) have an important role to play (Peltormäki 2009). Traditionally, most building energy analyses have been conducted late in design (Stumpf et al. 2011). However, today's simulation software allows any aspect of a design's performance to be simulated and assessed before it is built, helping project teams to understand the design more completely and to make energy conscious decisions. At its best, this method results in more efficient designs and greater energy efficiency (Beaven 2011). Most of the data needed in IT supported energy analysis is described in the Building Information Model (BIM-model). However, the BIM process requires a high level of communication and understood work flows to support its fullest capabilities. Therefore, a common understanding is needed (Laine et al. 2007). This is achieved by using Information Delivery Manuals (IDMs), which provide the integrated reference for process and data required by BIM (Wix et al. 2010). The complete process is illustrated in Figure 1 below.

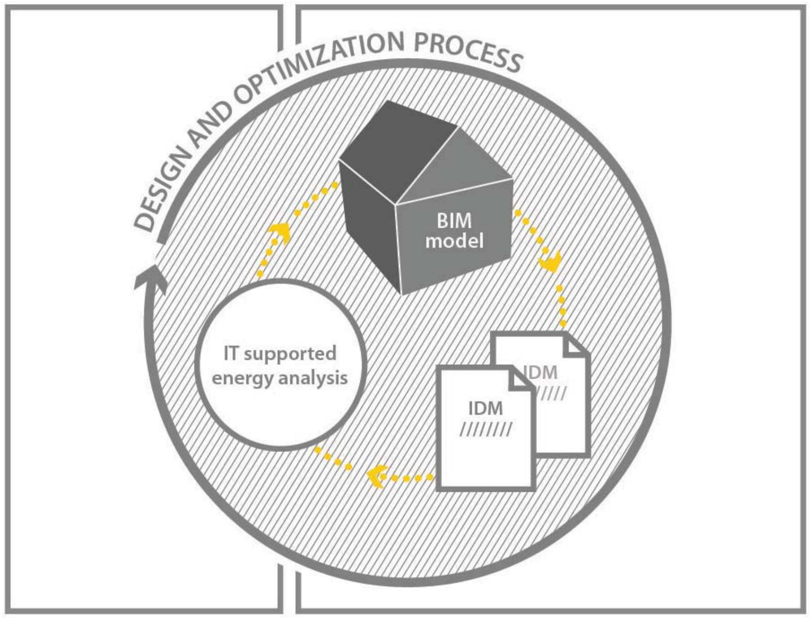

Figure 1: IT supported energy analysis using BIM and IDMs

1.3 Multifaceted Study

This study has two goals. The first is to explore the processes and approaches to energy efficiency in the Öresund Architecture, Engineering, and Construction (AEC) industry. The second is to develop a common IDM to facilitating IT supported energy analysis at concept design phase. Using a variety of research methods, this study includes the following: (1) a review of current approaches to IT supported energy analysis to understand the background, (2) a survey of Danish and Swedish industry professionals to gain an understanding of their knowledge and experience of IT supported energy analysis, and (3) mapping of Danish, Swedish, and international simulation tools to get an overview of existing software.

2. METHODOLOGY

2.1 Review of Current Approaches

Review of current approaches on IT supported energy analysis and utilization of IDMs has been conducted. The review includes guidelines generated by regulatory and government institutions, white papers and technical reports from vendors, and articles on the practice of computer aided energy analysis. For the purpose of the interregional study framework, the review focuses on the uptake of energy efficiency and IT supported energy analysis in the Öresund Region.

2.2 Survey of Industry Professionals

Semi structured interviews of industry professionals have been conducted. Interviews were conducted to gain industry inputs, primarily on computer aided energy analysis being a platform for energy efficient building design. The interviews were structured around a predetermined list of questions, to which the participants were invited to offer responses. The selection of participants was based on *purposive sampling* (Denscombe 2007). More specifically, the participants were *hand-picked* with a purpose in mind. In this study, the participant selection was based around the participant's organization's knowledge on IT supported energy analysis. The survey sample consisted of architects, engineers, and construction contractors. The diverse backgrounds of the participants provided a rich context for their inputs. For the purpose of the interregional study framework, the participants represented organizations from both Denmark and Sweden.

2.3 Mapping of Energy Simulation Tools

Mapping of selected Danish, Swedish and International energy simulation tools has been conducted. The mapping aims to highlight similarities and differences that exist, and to identify tool-specific exchange requirements for energy simulation input. By mapping existing tools, approaches for developing common IDMs are realized. The mapping involved data collection from Danish energy simulation tool Be10 (SBi 2011), Swedish IDA ICE (EQUA 2002), and International IESVE (IES 2012).

3. REVIEW

3.1 IT Supported Energy Analysis

The aim of conceptual design phase energy analysis is to "have an impact on the overall building design, and to determine the feasibility of concepts in an energy context" (See et al. 2011). With both IT supported energy analysis and BIM in growth, combining them allows project team members to predict thermal performance and overall energy consumption. In addition, real-time performance feedback during the concept phase also educates designers; "you see the changes and understand what is going on" (Malin 2007).

3.2 Energy Efficiency in the Öresund AEC Industry

The Öresund Region aims "to be Northern Europe's border regional powerhouse for sustainability, innovation, and green growth – and to become CO_2 neutral within 15-20 years" (Harboe 2011). Therefore, comprehensive approaches have been developed to support energy efficiency. For the purpose of adopting IT supported energy analysis, the Danish Building Regulations invite project teams to follow the calculation procedure described in *SBi-Direction 213: Energy Demands in Buildings* (Bygningsreglementet 2011). This publication includes the energy simulation tool Be10 (SBi 2011). In Denmark, a Be10 energy calculation is required from any project team seeking construction permits. That is, IT supported energy analysis to demonstrate compliance *before* constructing the actual building. In Sweden, no such requirements exist. Here, the building's performance and overall energy efficiency is measured and verified *after* constructing the building (Boverket 2009). However, to achieve such efficiency, the adoption of IT supported energy analysis appears fundamental. Consequently, energy simulation tools such as IDA ICE (EQUA 2002) are commonly used within the Swedish AEC industry.

3.3 IDM Technical Architecture

The Information Delivery Manual (IDM) is a process modeling language that has been proposed to define "information to be exchanged about a particular topic or business requirement in the construction process" (ISO 2010). The IDM architecture is illustrated in Figure 2 below.

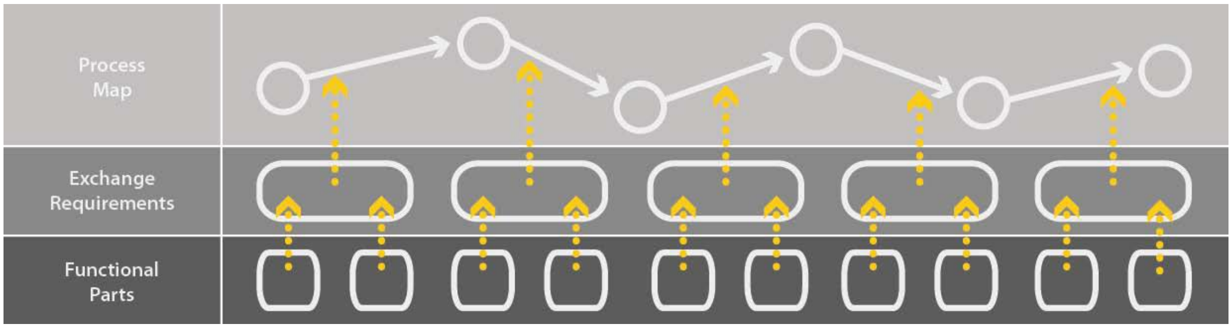

Figure 2: IDM technical architecture [Inspired by (Wix et al. 2010)]

As illustrated, the IDM architecture consists of a project map, a unit of exchange requirements, and a set of functional parts (Wix et al. 2010):

- Project Map (PM): Displays the flow of activities within a defined process.
- Exchange Requirements (ERs): Define the information that needs to be exchanged.
- Functional Parts (FPs): Define the information that supports the exchange requirements.

3.4 IDM for Energy Analysis

Several IDM developments have already been suggested, all including guidance on the analysis process and information exchange requirements (See et al. 2011). For the purpose of IT supported energy analysis, the IDM is considered to involve the following steps: (1) select type of energy analysis, (2) select type of energy simulation tool, (3) specify exchange requirements for energy analysis, (4) import data to energy simulation tool, and (5) perform energy analysis. The process is illustrated in Figure 3 below.

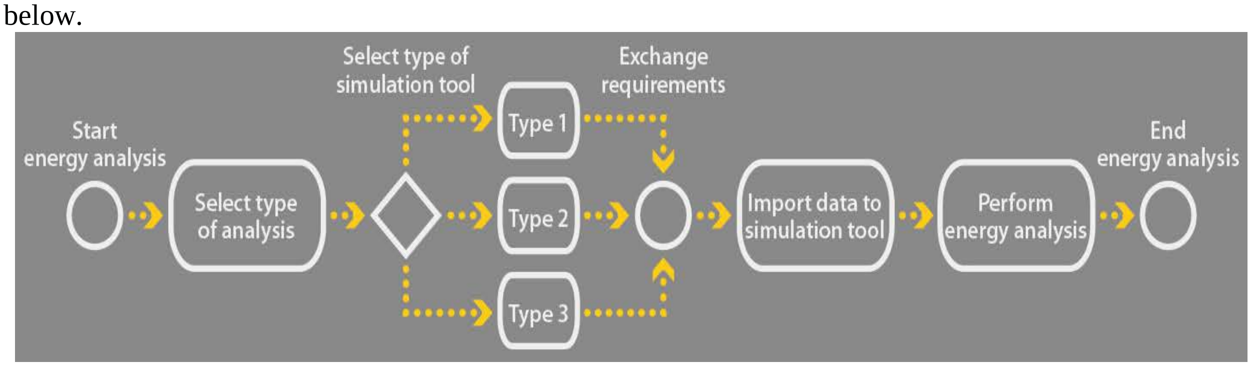

Figure 3: Conceptual PM for IT supported energy analysis [inspired by (See et al. 2011)]

4. SURVEY

4.1 Interview Questions Guide

The interview questions guide were split in to three different stages: (1) stage one questions established profile of the participants' organizations, (2) stage two questions identified the simulation tools used by the organizations, and (3) stage three questions investigated the issue of utilizing BIM and standardized guidelines in connection with IT supported energy analysis. The questions are summarized in the following:

(1) "What type of business does your organization represent?"
(1) "How many people are employed by your organization?"
(2) "Does your organization perform IT supported energy analysis?"
(2) "Which energy simulation tools does your organization use, and in which project phases?"
(3) "Does your organization use BIM to support IT supported energy analysis?"

(3) “Does your organization use standards to support IT supported energy analysis?”

4.2 Interview Analysis

Interviews were analyzed using a thematic approach, dividing the data into identified key issues. In the analysis we clearly demonstrated that adopting IT supported energy analysis involves functions of both technical, work practice, and process related matter:

- All surveyed participants highlighted the importance of incorporating IT supported building analysis at concept design phase, allowing project team members to design buildings that are more energy efficient.
- There are several energy simulation tools that can perform IT supported energy analysis. Based on survey responses, the most commonly used tools in Denmark include Be10 (SBi 2011) and IESVE (IES 2012), and in Sweden, IDA ICE (EQUA 2002) and VIP-Energy (StruSoft 2009).
- Although participants were generally interested in implementing the BIM-model as a data source for IT supported energy analysis, digital collaboration leads to a number of technical challenges, for example, getting the energy simulation tool and BIM-model to communicate properly.
- All participants highlighted the benefits of using common standards to support IT supported energy analysis, particularly, when collaborating across national borders.

5. MAPPING

5.1 Patterns of Mapping

For this study, energy simulation tools were tested for concept phase energy analysis. The tools that were tested were Danish Be10, Swedish IDA ICE, and International IESVE. Several kinds of correlations were mapped, including the following:

- In the mapping process, we found that Be10 calculates energy consumption only. IDA ICE and IESVE, however, allow simulation of both energy consumption and thermal performance.
- In addition, Be10 calculates energy consumption using a whole building approach, whereas IDA ICE and IESVE enable the simulation of thermal performance of individual zones, as well as energy consumption for the entire building. The concepts are illustrated in Figure 4 below.

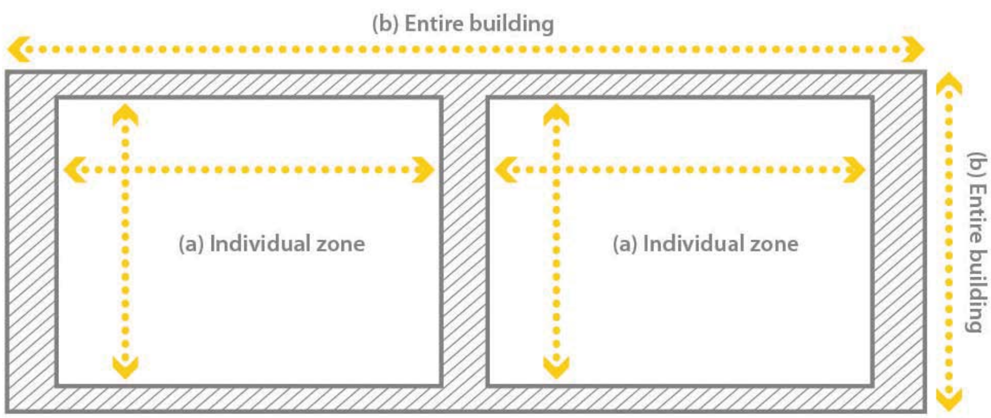

Figure 4: Analyzing (a) individual zones or (b) the entire building

- Another issue that was mapped was the different definitions of analytical room volumes (that is, the room volume that is used for thermal and energy calculations). In Be10, the analytical room volume is defined by the external dimensions, in IDA ICE, by the internal dimensions, and in IESVE, the volume is defined by the wall centre-line. The three different concepts are illustrated in Figure 5 below.

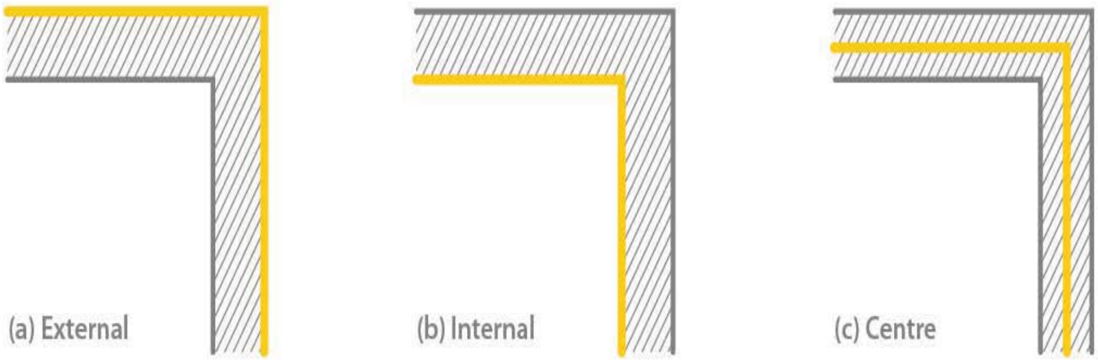

Figure 5: Analytical room volume using (a) external, (b) internal or (c) centre-line

6. CURRENT STUDIES

6.1 Tool-Specific Exchange Requirements

The current phase of our study involves mapping of tool-specific exchange requirements (that is, required data input for energy simulation tools Be10, IDA ICE, and IESVE). The exchange requirements include the following:

- Building type, location, geometry, composition, and orientation.
- Site context, elevation, surroundings, and adjacent buildings.
- Building construction and thermal properties of all elements.
- Building usage, usage profiles and functional use.
- Internal loads, schedules for electrical lighting, occupants, and equipment.
- Heating, ventilating, and air conditioning systems.
- Space conditioning requirements.

The mapping is structured around the buildingSMART development *Information Delivery Manual for Building Energy Analysis* (See et al. 2011), with the purpose of collecting the data in a predefined requirement scheme. The process is illustrated in Figure 6 below.

Type of Information	Information Needed	Required	Optional	Units
Building	The following properties should be included • Identification • Global Coordinates • Orientation	 X X X		 n/a Deg/Min/Sec Degrees
Building Elements	The following properties should be included • Building Element Type • Construction Type • 3D Geometry	 X X 	 X	 n/a n/a Varies

Figure 6: Exchange requirement scheme sample [inspired by (See et al. 2011)]

7. CONCLUSIONS

A comprehensive study of current approaches, survey of industry professionals in the Öresund Region, and mapping of available energy simulation tools have been conducted to gain input on IT supported energy analysis. The mapping of tool-specific exchange requirements is currently being conducted to demonstrate similarities and differences, and to identify deficiencies. Based on this, layout for the development of an IDM has been planned. In the next stage, a common interregional IDM will be generated, as well as specifications and guidelines for implementing it in practice.

Note: The interregional IDM will be presented on the website www.bygbygg.org with the purpose of functioning as an online *translator* of Danish and Swedish BIM approaches. This may appear beneficial, when collaborating across the Öresund Region.

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