BIM-frukost: Energieffektiv arkitektur med BIM

BIM Alliance Sweden

Marie-France Stendal

06.12.2023

Credit: Maxiphoto

14TH EUROPEAN CONFERENCE ON PRODUCT AND PROCESS MODELLING

TRONDHEIM, NORWAY

14 to 16 SEP. 2022

Predicting annual heating energy use using BIM: a simplified method for early design phase

Marie-France Stendal

Faculty of Engineering LTH

Lund, Sweden

Access to Document

doi:10.1201/9781003354222-40

https://www.taylorfrancis.com/chapters/edit/10.1201/9781003354222-40/predicting-annual-heating-energy-use-using-bim-simplified-method-early-design-phase-stendahl-dubois

BEM to BIM in the early design phase: A comparison between static and dynamic heating energy predictions

M F Stendal[1,*], T Ferreira[2], M C Dubois[1]

[1]Lund University, Faculty of Engineering (LTH), Department of Building and Environmental Technology, Division of Energy and Building Design (EBD), Lund, Sweden Country

[2] White Arkitekter, Östgötagatan 100, Stockholm, Sweden

[*] Corresponding author: marie-france.stendal@ebd.lth.se

Abstract

Due to climate change and increasing pressures on resources, the demand for more energy-efficient buildings is increasing globally.

Building information modeling (BIM) and building energy modeling (BEM) are two essential tools to make the necessary transition to net-zero energy buildings (NZEB).

This article presents two case studies aiming to automate information from the BIM model to predict annual heating energy use at the early design phase (EDP) using static energy calculations.

Additionally a comparison was presented between results obtained with the static and dynamic energy calculations with the building energy simulation (BES) package IDA-ICE.

The goal of the static calculations is to allow working directly in the BIM model in real time to obtain annual energy use based on building surfaces, heated floor area, heated volume, and other inputs related to the heating degree-day (HDD) method.

Theory

Static energy models are typically used to estimate building energy use under the assumption that the internal and external environments are in a steady state.

A known advantage of the static energy model is its simplicity. However, **the precision is normally limited (±25% error) because solar energy and the changes in environmental variables** (external weather, internal heat loads, and thermal capacity of the building structure) over time are not considered.

In general, the dynamic energy model is preferred since detailed energy flows can be calculated more accurately than with the static energy model.

±25%

Precision of static energy calculations due to the fact that environmental variables are not included.

1 Static energy models — Simplicity

2 Dynamic energy models — Accuracy

Method

Geometries

This section presents the two case studies used to validate the methodology.

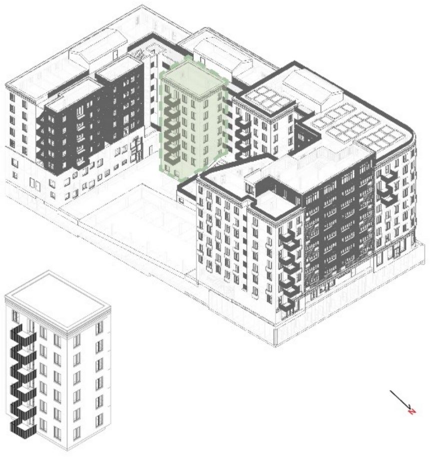


Figure 1. Revit screenshot of Eskilshem (top) and its isolated block for the energy analysis.

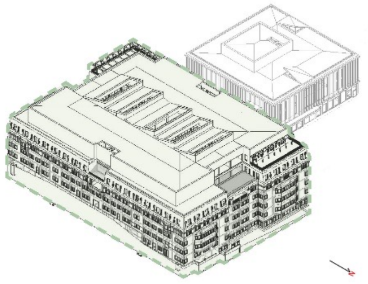


Figure 2. Revit screenshot of Huddinge city hall, the renovated part for the energy analysis (top) and the addition, the new library (bottom).

Results

Eskilshem had to comply with a more ambitious energy-efficiency target through the Swedish 'Miljöbyggnad Silver' environmental certification system, which limits its primary energy use to 80% of building code level (thus 68 kWh/m², year for total primary energy use).

Note that the primary energy use target in Miljöbyggnad includes the same end-uses as the national building energy code i.e., heating, ventilation, cooling, DHW, and property electricity. Electricity use by the user (plug loads, electric lighting) is not included.

The Huddinge case also had to demonstrate compliance with 'Miljöbyggnad Guld' system, which sets the limit at 42 kWh/m² (60% of building code level).

The results for heating and DHW annual primary energy use obtained with both static and dynamic calculations are presented in Figure 3.

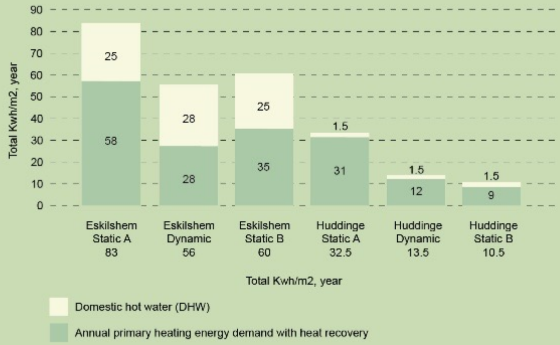


Figure 3. Results of the annual energy use from the Static A, Dynamic, and Static B calculations.

22%

Percentage difference between Dynamic and Static B calculations for the annual primary heating energy for Eskilshem.

28%

Percentage difference between Dynamic and Static B calculations for the annual primary heating energy for Huddinge.

Discussion and conclusions

➔ The results indicate that the static energy calculations for the annual primary heating energy after integrating the internal heat loads (Static B) differ by ±25% compared with the dynamic energy calculations performed with the IDA-ICE software, which is in line with earlier studies.

➔ Although this deviation is non-negligible, it is acceptable at very early design stages, when little information about the project is available.

➔ The advantage of static energy calculations is that they do not require any post-processing or conversion of the BIM file to other formats, which has been found to be time consuming in real building projects. The static calculations can be performed in real time within the BIM environment and thereby guide the architect iteratively in the EDP.

➔ The next step in this project will consist of including several other case studies to more precisely determine input data, such as the heating set point.

➔ This will be followed by the implementation of necessary programming features in the BIM environment to automate the energy prediction for real time information to the architect.

➔ This will also facilitate the further transition to a dynamic model at a later phase in the design since the modeler will have to assign thermal zones preparing for the dynamic calculation.

Access to Document doi:10.1088/1742-6596/2600/6/062006

https://iopscience.iop.org/article/10.1088/1742-6596/2600/6/0620

Associate professor
Marie-Claude Dubois
supervisor

LUND
UNIVERSITY

Professor Eilif Hjelseth
co-supervisor

NTNU

Professor Daniel Forgues
co-supervisor

ÉTS

Associate professor
Marie-Claude Dubois
supervisor

Professor Eilif Hjelseth
co-supervisor

Professor Daniel Forgues
co-supervisor

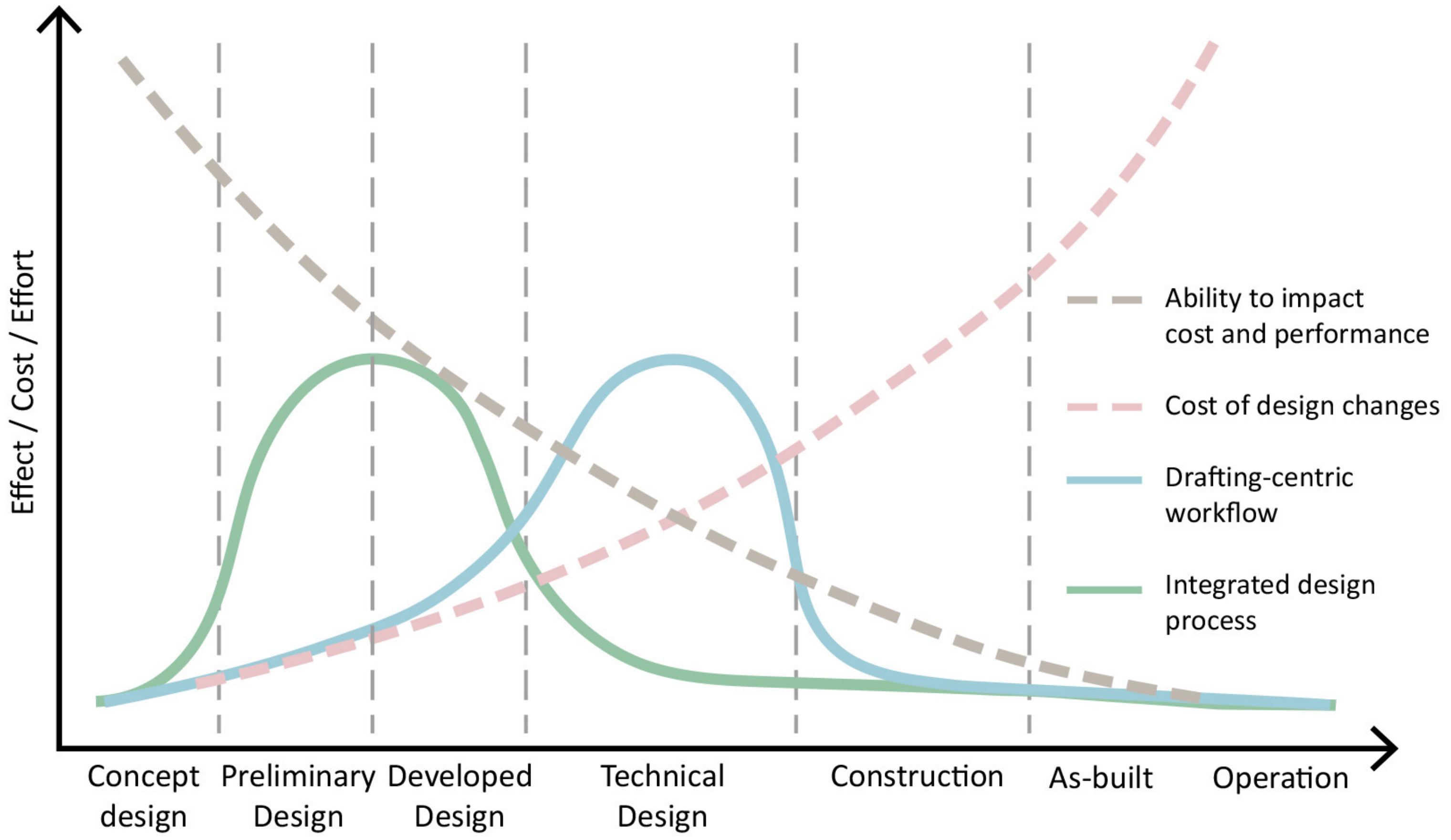
BIM-to-BEM

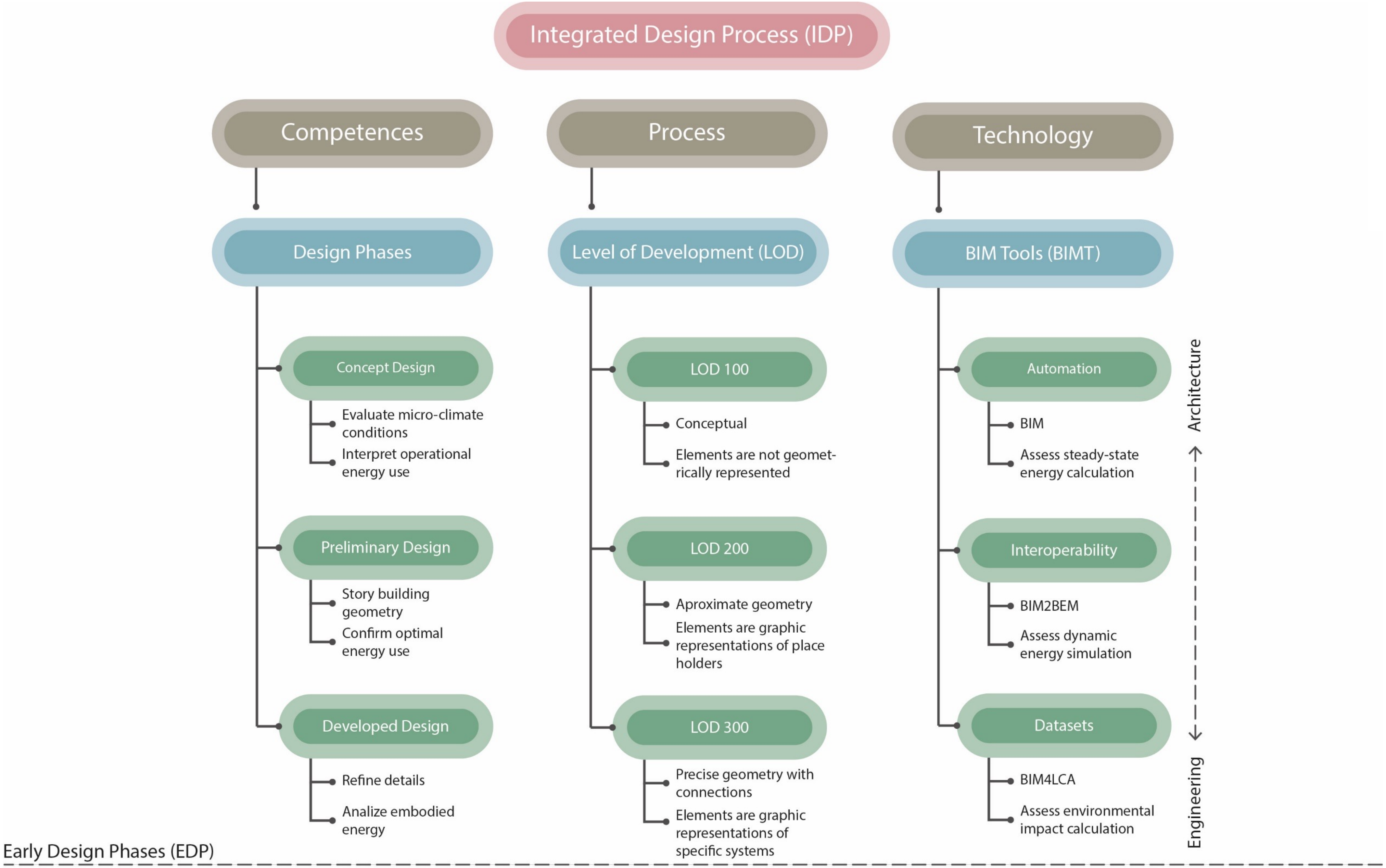
Source: Fortress planning

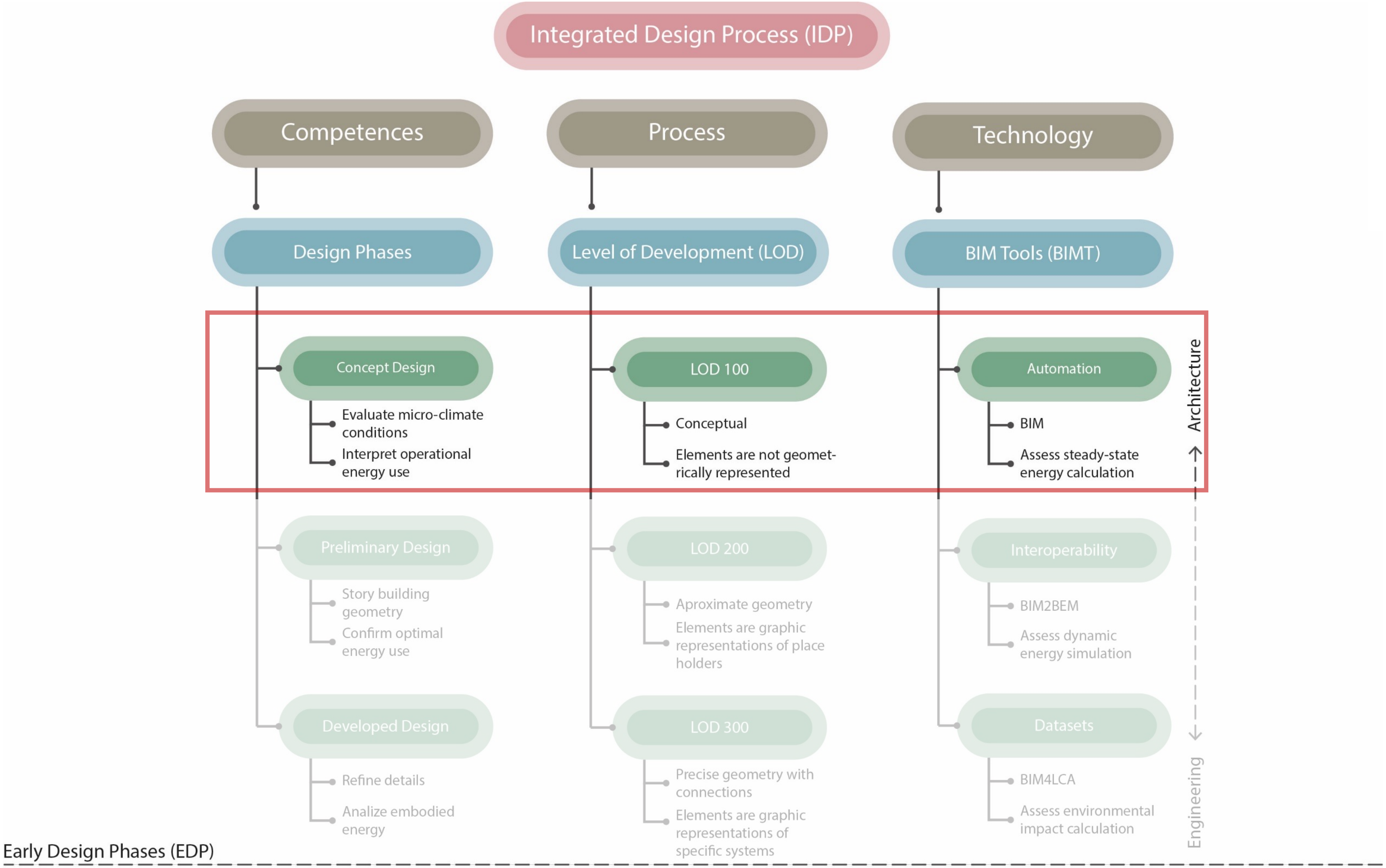
BEM-to-BIM

Source: Fortress planning

Integrated Design Process (IDP)

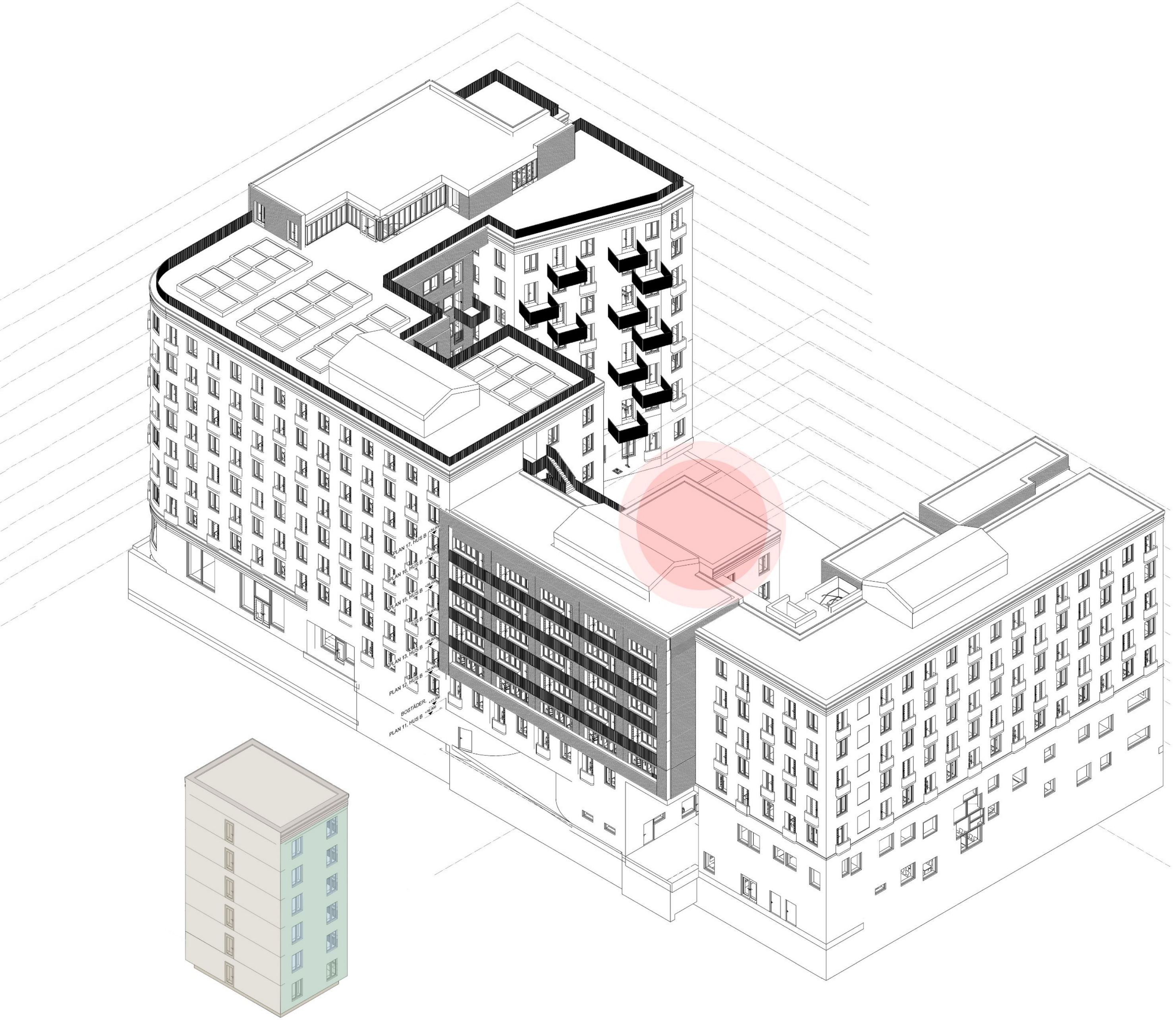



Integrated Design Process (IDP)
Competences
Process
Technology
Design Phases
Level of Development (LOD)
BIM Tools (BIMT)
Concept Design
Evaluate micro-climate conditions
Interpret operational energy use
Preliminary Design
Story building geometry
Confirm optimal energy use
Developed Design
Refine details
Analize embodied energy
LOD 100
Conceptual
Elements are not geometrically represented
LOD 200
Aproximate geometry
Elements are graphic representations of place holders
LOD 300
Precise geometry with connections
Elements are graphic representations of specific systems
Automation
BIM
Assess steady-state energy calculation
Interoperability
BIM2BEM
Assess dynamic energy simulation
Datasets
BIM4LCA
Assess environmental impact calculation
Architecture
Engineering
Early Design Phases (EDP)



Integrated Design Process (IDP)
Competences
Process
Technology
Design Phases
Level of Development (LOD)
BIM Tools (BIMT)
Concept Design
Evaluate micro-climate conditions
Interpret operational energy use
LOD 100
Conceptual
Elements are not geometrically represented
Automation
BIM
Assess steady-state energy calculation
Architecture
Preliminary Design
Story building geometry
Confirm optimal energy use
LOD 200
Aproximate geometry
Elements are graphic representations of place holders
Interoperability
BIM2BEM
Assess dynamic energy simulation
Developed Design
Refine details
Analize embodied energy
LOD 300
Precise geometry with connections
Elements are graphic representations of specific systems
Datasets
BIM4LCA
Assess environmental impact calculation
Engineering
Early Design Phases (EDP)

Eskilshem - Sweden



First step

Second step

Degree days and hours

(1) $HDD = (T_{ref} - T_{out}) \cdot 365$ °C, day

Annual heat losses by conduction

(2) $Q_{\_cond} = (U \cdot A) \cdot HDD \cdot 24$ Wh

Heat losses by mechanical ventilation + air leakage

(3) $q_{\_vent\_total} = \rho \cdot c_p \cdot \varphi_{\_vent} (1 - \eta) + \rho \cdot c_p \cdot \varphi_{\_leak}$ W/°C

In absence of ventilation requirements in the building code

(4) $\varphi_{\_vent} = ach \cdot V$ W/°C

Air leakage

(5) $q_{\_leak} = \rho \cdot c_p \cdot \varphi_{\_leak}$ W/°C

Annual heat losses by mechanical ventilation + air leakage

(6) $Q_{\_vent\_total} = q_{\_vent\_total} \cdot HDD \cdot 24$ Wh

Annual heating energy use

(7) $Q_{\_heating} = Q_{\_cond} + Q_{\_vent\_total}$ Wh

$65\ kWh/m^2$, year heating

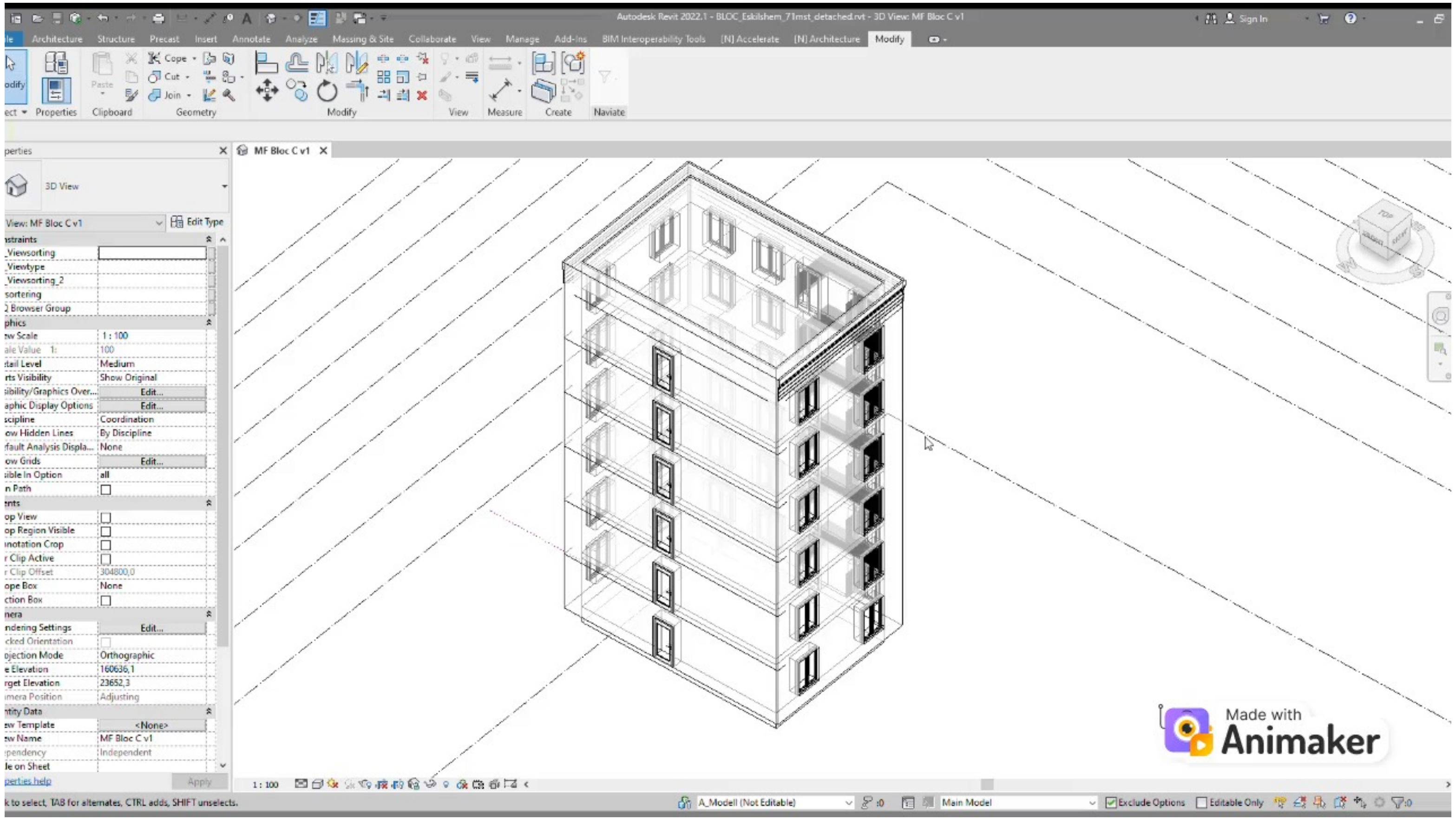
$68\ kWh/m^2$, year total

Manual vs. Simulations

$58\ kWh/\ m^2$, year vs. $28\ kWh/\ m^2$, year

Internal heat loads

$35\ kWh/\ m^2$, year vs $28\ kWh/\ m^2$, year



Autodesk Revit 2022.1 - BLOC_Eskilshem_71mst_detached.rvt - 3D View: MF Bloc C v1
Architecture Structure Precast Insert Annotate Analyze Massing & Site Collaborate View Manage Add-Ins BIM Interoperability Tools [N] Accelerate [N] Architecture Modify
Properties Clipboard Geometry Modify View Measure Create
MF Bloc C v1
3D View
View: MF Bloc C v1
Edit Type
Medium
Show Original
Coordination
By Discipline
Orthographic
MF Bloc C v1
Independent
1 : 100
A_Modell (Not Editable)
Main Model
Exclude Options
Editable Only
Made with
Animaker

EBC

Energy in Buildings and Communities Programme

International Energy Agency (IEA)

Energy in Buildings and Communities Programme (EBC)

Open BIM for Energy Efficient Buildings

iea

EBC is a programme of the International Energy Agency (IEA)

Energimyndigheten

E2B2

LTH LUNDS TEKNISKA HÖGSKOLA

KTH VETENSKAP OCH KONST

buildingSMART International

To summarize

- improved process for energy calculations

  primarily due to the challenges posed by interoperability between BIM and BEM

- tool development

  development of tools can facilitate the integration of BIM and BEM

- novel concept BEM-to-BIM integration

  BIM industry should focus on integrating energy calculations directly within the BIM environment

Tack!

Marie-France Stendal
marie-france.stendal@ebd.lth.se
@whitearkitekter

Credit: Maxiphoto