Module 14

Tools for Energy Efficiency

Digitalisation in Construction

*Date of Event*

*Author/ Institute*
To equip the learner with the basic knowledge and skills required to understand and know how BIM and other digital tools can improve the energy performance of buildings.
1. List and outline how the use of digital tools can improve the energy efficiency of buildings.

2. Outline how a BIM model can be used to perform an energy analysis.

3. Outline how to develop a Building Energy Model (BEM).

4. Demonstrate how to develop a Building Energy Model (BEM) using a case study.

5. Outline how using a BEM affects the design and operation of nZEB buildings.

6. Outline the process of delivering a BEM to an energy simulation tool.
Topic 1 – Energy Efficiency Tools

Topic 2 – Energy simulation tools
1. Energy Efficiency Tools
In Europe

- The construction of quality efficient buildings is important and is the responsibility of all involved.
- NZEB policies and Green directives have set out an action plan for the construction industry.
- “Construction of energy efficient, healthy, sustainable buildings”
  - Energy Efficiency Directive
  - The European Green Deal

Summary NZEB

EU POLICIES & LEGISLATION

- 1997 - Kyoto Agreement
  - EU Directive to improve energy efficiency and reduce GHG emissions
  - Improve energy performance for new and existing buildings
- 2010 - EPBD Recast
  - To achieve nearly zero energy buildings NZEB, mainly using renewable energies by 2020.
- 2012 - Energy Efficiency Directive (EED)
  - To use energy more efficiently at all stages of the energy chain from its production to its final consumption
- National Building Codes
- 2018 - EPBD Recast
  - Decarbonise building stock by 2050, smart technologies and the mobilisation of investments
- 2020 - The European Green Deal
  - Circular Economy Action Plan, Renovation Wave Initiative and smart sector integration

Source: BIMzeED project
Nearly Zero Energy Buildings means a building that has a very high energy performance, Annex 1 of the Directive, and in which “the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby”.

- A building which produces more or less the same amount of energy per year as it uses.
- The building can generate this renewable energy on site or feed back to the electricity grid.
Why go NZEB?

“To construct quality, healthy, energy efficient buildings”

Occupants –
- By improving energy savings, comfort levels, indoor air quality (IAQ), healthy living, reduce fuel poverty

Building Owners –
- By improving building value, quality dwellings, lower maintenance, improve image,

Contractors –
- By streamlining work schedules, improve costs, improve image, trained workforce, job creation

Also it is Law!

Energy savings
Comfort
IAQ

Increasing buildings’ energy performance is one of the most cost-effective ways to reach the EU climate goals and to stimulate sustainable growth. It will lead to important social and environmental benefits and give a boost to Europe’s economy.

Source: BIMzeED project
Key principles of energy usage and waste

**Building Envelope**

The building envelope separates the outdoor environment from the conditions inside the building. It consists of walls, doors, windows, floors and roof.

The envelope controls the flow of heat energy, air movement, moisture penetration, and solar heat, to maintain the indoor conditions within a range that is convenient to the occupants' comfort, health, safety and purse!

To maintain required conditions inside the building space, the building systems must overcome the energy loads that are imposed by the climatic conditions outside the building and also, energy loads that are imposed by factors inside the building itself.

Source: BIMzeED project

Source: SEAI:
Heat Losses and Gains
The transmission of heat energy through the solid elements of the building envelope is caused by the difference between the indoor and outdoor temperatures. The materials used in the building envelope have a significant impact on the amount of energy required to maintain a suitable environment within the building space. Building walls composed primarily of glass and steel are a major source of heat loss in the winter and heat gains in the summer.

Heat is transmitted through the building envelope in three ways:
1. Conduction is the heat flow through a solid material from the warmer to the cooler side of the envelope, through walls, roof/ceiling and floor slabs.
2. Convection is the heat transfer caused by the motion of heated air from a warmer to a cooler surface, thorough openings and cracks around windows and doors.
3. Radiation is the transfer of heat by electromagnetic waves from a warmer to a cooler surface. Solar radiation depends on: its location, time of year, time of day, the building’s orientation.

Source: BIMzeED project
Key principles of energy usage and waste

**Heat losses and gains**
Materials of different properties have different thermal conductivities of energy, and are compared on the basis of U-values and R-values. The thermal transmittance (U-value) identifies the ability of a material to conduct thermal energy. The thermal resistance coefficient (R-value) is the corresponding rate of thermal resistance of the material.

**Thermal Coefficients**
- Thermal Conductivity Coefficient $\lambda$ [W/(mK)] represents the properties of the material to conduct heat.
- Thermal Resistance Coefficient $R = \frac{d}{\lambda}$ [m2K/W]; $d =$ thickness of material; represents the properties of a building element to resist conductive transfer of heat per unit of exposed area.
- Heat Transfer Coefficient $U = \frac{1}{R}$ [W/m²K] represents the rate of transfer of heat through one square metre of a structure divided by the difference in temperature across the structure.
- Materials with better insulation properties have higher R-values
- Calculation of R for combination of materials : $R_{total} = \Sigma R_i$

Source: BIMzeED project
Energy Efficiency Tools

BIM can control quality and better design and construction of NZEB buildings

- Project Management and Coordination
- Sequencing and Scheduling
- Cost Estimation
- Time Management

BIM allows for better collaboration by all Teams

- Roles and Responsibilities
- Information Transfer

Source: BIMzeED project
VISUALIZATION PLATFORMS - Issue Management - BIMSynch

Free Trial: https://bimsync.com/

Source: BIMzeED project
Digitalisation in Construction: Tools for Energy Efficiency

Simplifies communication by connecting platforms via the cloud.
Resolve the issues that matter most in your everyday BIM software.
Analytics give you the information you need to make the right decisions.
BIM Track provides total accountability and transparency.

Source: BIMzeED project
Review the BIM-Viewer

There are several free BIM Viewers available in the market:

https://bimvision.eu/en/

https://www.dalux.com/daluxbimviewer/


https://solution.solibri.com/application/#!ProductsView

We will look at Navisworks Manage
VISUALIZATION PLATFORMS - Solibri

https://www.solibri.com/solibri-anywhere

Source: BIMzeED project
VISUALIZATION PLATFORMS - BIMVision

Read more and download: https://bimvision.eu/

Source: BIMzeED project
NZEB for Carpenters
NZEB for Bricklayers
Digitalisation in Construction: Tools for Energy Efficiency

CDE - Trimble Connect/ Aconnex/ ThinkProject/ Dalux

Source: BIMzeED project
Digitalisation in Construction: Tools for Energy Efficiency

CDE - Autodesk B360

Source: BIMzeED project

https://www.autodesk.com/bim-360/
Digitalisation in Construction: Tools for Energy Efficiency

Source: BIMzeED project

VISUALIZATION PLATFORMS - Autodesk Navisworks

Source: BIMzeED project
Access and Navigate Data

What is Navisworks?

Use Navisworks® project review software to improve BIM (Building Information Modelling) coordination.

1. Combine design and construction data into a single model.
2. Identify and resolve clash and interference problems before construction.
3. Aggregate data from multiple trades to better control outcomes.
BIM System Requirements

Before downloading the applications check that the system requirements.

See the following sections for hardware and software requirements:

Single Installation Requirements
Microsoft® Windows® 10 (64-bit) on the Semi Annual Channel servicing option.
Intel® Pentium® 4 or AMD Athlon™ 3.0 GHz (or higher) with SSE2 technology
2 GB RAM (minimum)
15 GB free disk space for installation
Direct3D 9° and OpenGL® capable graphics card with Shader Model 2 (minimum)
1,280 x 800 VGA display with true color (1,920 x 1,080 monitor and 32-bit video display adapter recommended)
Microsoft Mouse-compliant pointing device
Microsoft® Internet Explorer® 8.0 or later
Navisworks Download

Video lessons related to NavisWorks were developed using the BIM tool **NavisWorks Manage**

Students can download a free Navisworks Manage student account.

You can use the following link for download 2021:
Navisworks_Manage_2021_dlm.sfx.exe
https://www.autodesk.com/education/free-software/navisworks-manage

**Install**

Run the downloaded executable to unpack the Manage installer to a location of your choice and to begin the installation process. Note that administration rights are needed to install this product.

**Learn more**

A Readme, Installation Guide, and other important documentation are accessible from within the installer. Navisworks Manage includes a comprehensive help system.

Source: BIMzeED project
ALL THE BIM RELATED EXERCISES CAN ALSO BE PERFORMED IN OTHER BIM TOOLS

- Revit [https://www.autodesk.eu/free-trials](https://www.autodesk.eu/free-trials) or
- 3D Rhinoceros ETC ETC

It’s all about the principles, and the principles remain unchanged regardless of the tools used.
Navisworks Exercises
VISUALIZATION PLATFORMS - Navisworks

- THEORY BEHIND THE TASK

1- User Interface (Selection Tree, Properties, Sets, Find Items, Saved Viewpoints)

2- Units of Navisworks File

3- Types of Navisworks Files
   - NWF: Navisworks File
   - NWD: Navisworks Document
   - NWC: Navisworks Caché

4- Gridlines

5- Navigation

6- Viewpoints

7- Comments
Open Screencast from Autodesk to record your screen and carry out the following steps:

1. Open a Navisworks file
2. Organize your User Interface as you desire to show Selection Tree, Properties, Saved Viewpoints.
3. Append all the files of the folder provided.
4. Show Gridlines.
5. Navigate through the Project and save relevant Viewpoints. Include Sections of the Model.
6. Organize the views in Navisworks folders.
7. Show Properties of a particular Element.
Digitalisation in Construction: Tools for Energy Efficiency

Source: BIMzeED project
VISUALIZATION PLATFORMS – Navisworks-Units

Source: BIMzeED project
VISUALIZATION PLATFORMS – Navisworks - Gridlines

Source: BIMzeED project
VISUALIZATION PLATFORMS – Navisworks -Navigation

- Walk Mode (Shift)
- Fly Mode
- Realism
- Collision
- Gravity
- Crouch
- Third Person

Source: BIMzeED project
Digitalisation in Construction: Tools for Energy Efficiency

Source: BIMzeED project
Comments can be associated with selection sets, search sets, saved views, animations, clashes, and tasks.
Review the BIM-Viewer

What is a BIM-Viewer?

An App/Tool that allows the easy sharing of drawings, IFC and BIM models.

This is to help workers to:-

➢ Visualise the building by viewing, [location of columns]
➢ Compare sheets to see changes in real-time [reviews and log activity]
➢ Confirm what information is needed, [floor finishes, size of window opening].
➢ Report a problem in the viewer, [marking and highlighting service clashes]
➢ Check the delivery of materials on site, [time of arrival and quantity of concrete],

Source: BIMzeED project
Access and Navigate Data

Work within a cloud-based Common Data Environment (CDE) for the purposes of construction site and office activity.

- **Connect to Navisworks Manage**
  Understand the benefits of BIM and Navisworks

- **Access and follow the BIM Navisworks**
  Manage and export/import suitable data and information from Revit/AllPlan to Navisworks model for the purposes of construction site and office activity.

Source: BIMzeED project
Navisworks on Site

- In general, the construction-phase of the BIM model provides information used for:
  - coordination amongst trades,
  - clash detection,
  - quantification
  - installation and maintenance procedures.

- Navisworks will demonstrate how BIM can help to achieve NZEB and quality works on site using a number of video lessons and tutorials.
Navisworks on Site
Control schedules and costs using 4D and 5D simulation

- Animate and interact with model objects for simulation.
- Create schedules directly from project models.
- Import schedules and cost items from external project management applications.

Source: BIMzeED project
Navisworks on Site

Capture material quantities from 2D or 3D designs

- Measure lines, areas, and counts from 2D sheets or 3D models.
- Create synchronized project views that combine Revit and AutoCAD files, including geometry, images, and data.
- Export take off data to Excel for analysis

Analyse the whole project during preconstruction

Source: BIMzeED project
Practice Navisworks Manage using the videos provided for reference.

Part 1a Refresh house
Part 1b Navisworks and Revit
Part 2 Federated Model (6.51min)
Part 3 Viewpoint (9.06min)
Part 4 Item Selection (4.26min)
Part 5 Clash Detection (16.18)
Part 6 Timeliner (15.14)
Part 7 Quantifications (13.27)

Source: BIMzeED project
Navisworks Video Review

- Video Part 1a: Navisworks Refresher
- Explains the benefits of linking Revit Model to Navisworks model

Source: BIMzeED project
Navisworks Video Review

- Video Part 1b Navisworks and Revit
- Learn how Revit and Navisworks are connected

Source: BIMzeED project
Part 1a: Navisworks Refresher

Learning Outcome: Benefit of linking Revit/AllPlan Model to Navisworks Model

Navisworks will update automatically if linked to REVIT/AllPlan Model.
Save changes
Refresh and open Navisworks model
Access and Navigate Data - Lessons

Part 1b: Navisworks and Revit

Learning Outcome: Learn how Revit and Navisworks are connected.

Import/Export data and information from Revit/AllPlan model to Navisworks
Differences in Navisworks, freedom, simulate and manage
Review Revit
External tools – export and add-ins
Save NWC files in a safe location
Generate Plans and external tools

Source: BIMzeED project
Part 2: Federated Model and Navigate

**Learning Outcome:** Learn how to create a Federated Model

Open Navisworks Manage.

A number of tools will be presented:
- **Append** – select a number of NWC files
- **Viewports** – navigate around the building
- **Walk** – in/out motion and rotation of building
- **Gravity** – walk through the building
Part 3: Viewpoint and Revit

Learning Outcome: Learn about the functions ‘Viewpoint’ and ‘Review’

A number of Tools will be presented:

- Viewpoint – snapshot of a view which can be marked up.
- Review – comment on the mark up
- Measure – use temporary measurements and convert
- Draw – highlight parts of the drawing
- Text – annotate the view
- Sectioning – create a section
- Fit Selection – moving the cutting plane
- Add tag – tag and comment on an element
Part 4: Item Selection
Learning Outcome: How to locate and select elements.

Learn how to select element properties using:
• Properties tree
• Selection tree.

Source: BIMzeED project
Navisworks Video Review

Clash Detection

- Knowing what is possible with this software helps to inform site workers of the potential of such tools in avoiding problems on site. Engagement between site workers and Navisworks experts is the key to using the tool successfully.

- Clash detection should mainly be completed during the design phase. However it can be very useful in checking the set up of works or with renovation works as information missed at design stage can be sent directly to the rest of team highlighting any issues, clashes or comments.

- Ideally, clash detections are run before a project starts on site, otherwise much of the cost/time saving potential will have been missed.
Part 5: Clash Detection
Learning Outcome: How to use clash detection.

Select Clash Detection and Add Test.
Tolerance – review of tolerances
Surface Clashes
Self-Intersect clashes
New Group function
Resolved – active, reviewed, approved
Clash Report and snaps

Source: BIMzeED project
Timeliner

- BIM tools are not just for design or graphical purposes, but can assist with management sequencing.

Timeliner is available on Manage and Simulate

- It is an ideal tool for project managers or the main contractor.
- It enables time and cost planning management by setting out timeframes, tasks and costs associated to these tasks.
- It is ideal for site supervisors to check for any gaps or deviations from the planned schedules or budgets and how many workers are needed to get the job completed on time and in budget.
**Navisworks Video - Lessons**

**Part 6: NavisWorks Timeliner**

**Learning Outcome:** How to create a timeline simulation

- Used for construction sequencing
- Classify types of works—Construct, Demolish, Temporary,
- Appearance definition
- Planning – planned and actual
- Create a Set
- Task sequencing
- Simulate

Source: BIMzeED project
Navisworks Video - Review

Quantifications
This is one of the core functional features of Navisworks, creating a highly accurate quantity takeoff linked to the model. It allows you to see items that have been accounted for—and those that have not—and make sure you produce accurate material estimates and quantities. This is important as it allows for the extraction of key information from the model and project, to assess materials costs, quantities and order items when required.

Glossary before you start:-
Quantification Workbook
The main workspace that contains the object data for the takeoffs you create in a project.
Item Catalog
The organisational database for your takeoff project, defining takeoff groups and disciplines.
Resource Catalog
The resources needed for successful completion of a project, related by function and type including materials, equipment or tools.
Part 7 Quantifications

- **Learning Outcome**: how to use the quantification tool in Navisworks and
- Used to export an excel quantities file from Navisworks.
- Set up a Project - Qualification Workbook
- Item and Resource Catalogs -
  - Catalogs and COBie
  - Uniformat
  - Folders
- Model takeoff - Export Quantities to Excel
2. Energy Simulation Tools
The implementation of BIM for energy efficiency will provide energy savings through the combination of:
- accurate energy monitoring
- real-time data analysis, behavior modelling and real-time decisions
- identification of consumption patterns.
- enhanced supervision of energy flows and use in buildings
- new partnerships between energy managers, energy distributors, energy equipment suppliers, and technology (including smart software tools)

All this will inform the optimal management of the evolution of energy use in buildings, and result in a quantifiable energy consumption reduction.

The application of NZEB in BIM projects is done through the connection between BIM and BEM (Building Energy Modelling) software.

So with NZEB & BIM together, the European construction industry have the opportunity to:
1. Reduce energy demand
2. Reduce carbon emissions
3. Improve process efficiency

Source: BIMzeED project
BEM Benefits:

➢ Versatile, multi-purpose tool that is used in new building and retrofit design
➢ Provide code compliance and green certification
➢ Qualification for tax credits and utility incentives
➢ Real-time building control.

BEM is also used in large-scale analyses to develop building energy-efficiency codes and inform policy decisions.
BIM to BEM

Generic BIM to BEM project workflow

Depending on the BEM (Building Energy Modelling) tool that we will use, the workflow may vary. Some common steps to enable interaction between BIM and BEM tools are:
1. Set the site location
2. Define building form and levels
3. Create building envelope based on energy necessities
4. Export BIM model
5. Import the BIM into BEM tools
6. Fix or adjust the imported model
7. Run energy simulation
8. Extract and output results

Source: BIMEET EU PROJECT. D3.1
**INPUTS**

It’s important to check that all the required inputs to support energy simulations are set in the BIM Models and successfully transferred while importing to BEM tools. Inputs related with:

- Building program
- Building form
- Building envelope
- Equipment

Source: BIMEET EU PROJECT. D3.1 – Table 3 – Inputs required for energy simulation
**OUTPUTS**

If all the inputs are correctly set and transferred, we will be able to analyse the results:

- Thermal needs
- Delivered energy
- Primary energy
- Emissions

<table>
<thead>
<tr>
<th>Thermal Needs</th>
<th>Delivered Energy</th>
<th>Primary Energy</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Load</td>
<td>Heating</td>
<td>considering source factor of energy carriers</td>
<td>CO₂, NOₓ, SOₓ, and etc.</td>
</tr>
<tr>
<td>Cooling Load</td>
<td>Cooling</td>
<td>Electricity, NG, Fuel Oil, and etc.</td>
<td></td>
</tr>
<tr>
<td>Internal and External</td>
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<td>Lighting</td>
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<td>Internal and External</td>
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<td>Equipment</td>
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<td>Fan and Pump</td>
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</tbody>
</table>

Source: BIMEET EU PROJECT. D3.1 – Table 4 – Results from energy simulation
BIM & BEM integration workflow

R16 - provide guidance for using building and equipment
R21 - perform energy audit and assessment of building with BIM-based approach
R23 - provide consultancy on energy efficiency and indoor climate targets
R24 - engage with clients on the BIM requirements implied by EE regulations compliance
R25 - develop models and simulations to simulate energy performance of a project: optimize architectural design, calculate energy consumptions, life cycle costs, carbon footprint
R26 - simulate the effects of the design development: thermal bridges, illuminance, etc.
R34 - manage and repair conflicts
R35 - educate FM and users how building is operated

Figure 40 example of BIM to BEM workflow with some identified responsibilities. Software used here are Revit and Pélades.

Source: BIMEET EU PROJECT. D3.1 – Figure 40
BIM & BEM integration challenges

It is therefore important to ensure some tools or strategies should enable integration between BEM and BIM to finally achieve quality NZEB Buildings.

➢ Define the process through project standards and workflow criteria
   We need to create BIM Models which are helpful for many BIM uses to ensure that they will be usable to analyse and create the appropriate BIM standards in order to assure the achievement of the project goals.

➢ Specialized software and training for different agents
   Often it can be complicated to use these type of tools and requires experts in the management of these tools.

➢ Collaboration
   As much as we apply good processes and have the best trained team, we need to collaborate and share information. We need to define mechanisms that allow us to share information, as efficiently as possible, in order to optimize information transfers in the context of a project.
Energy design modelling: characteristics

- Control of the data provided by other tools — control of the different models:

- Architectural model — definition of spaces and enclosures; compartmentalisation elements; characteristics of materials.

- Structural model — definition of materials; definition of sections for the determination of thermal inertia and possible thermal bridges.

- Installations model — definition of different systems; definition of the equipment involved in the conditioning of spaces, indicating characteristics and performance.
Energy design modelling : tools

**CYPETHERM**
- Independent tool based on an openBIM workflow.
- It allows the analysis of models made by other programmes.

**Green Building Studio**
Autodesk web service that allows the energy performance and carbon footprint of a building to be assessed from the design phase and integrated into the Revit workflow.

**EcoDesigner**
- Plugin for Archicad, developed by Graphicsoft.
- Software that provides accurate data for each design so that the designer can opt for the most efficient solution when designing their building.

The Revit, ArchiCad and Openbuildings modellers include thermal analysis tools.

Source: SIBIM Project
QUIZ!
Thank You