Assessing buildings compliance with sustainability rating systems through a BIM-based approach

Paper session: Renovation

This project has received funding from the H2020 programme under Grant Agreement No. 820773
The team

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Open Project

Valentina Marino _ international activities
Green Building Council Italia

Mohamed Elagiry _ R&D project manager
R2M Solution
Presentation structure

- Green BIM state of the art
- BIM & LEED Intersection
- How many LEED credits can we automate with a BIM process?
- BIM4LEED Matrix
- BIM4LEED Case Studies
- Future development needs for BIM and LEED integration
What is Green BIM?

Green BIM is “a model-based process of generating and managing coordinated and consistent building data that facilitates the accomplishment of established sustainability goals”

(Wong & Zhou, 2015)
What is BIM 7D?

“7D - seventh dimension: Simulation of the building or of its elements according to the sustainability (economic, environmental, energy, etc.) of the intervention, as well as of space, time and production costs.”

(UNI 11337-1:2017)
What is LEED?

LEED, or Leadership in Energy and Environmental Design, is the most widely used green building rating system in the world. Available for virtually all building, community and home project types, LEED provides a framework to create healthy, highly efficient and cost-saving green buildings. LEED certification is a globally recognized symbol of sustainability achievement.
What is LEED?

5 Rating systems

Credit Categories

Each rating system is made up of a combination of credit categories. Within each of the credit categories, there are specific prerequisites projects must satisfy and a variety of credits projects can pursue to earn points. The number of points the project earns determines its level of LEED certification.
# LEED Credits

## LEED V4 for BD+C: New Construction and Major Renovation

### Project Checklist

#### Location and Transportation (16)

<table>
<thead>
<tr>
<th>Credit</th>
<th>Description</th>
<th>Y</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>LEED for Neighborhood Development Location</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>16</td>
<td>Site Development Management</td>
<td>N</td>
<td>N</td>
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<tr>
<td>17</td>
<td>High Priority Site</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>18</td>
<td>Sammutting Density and Mixed Uses</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>19</td>
<td>Access to Quality Transit</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>20</td>
<td>Bicycle Facilities</td>
<td>N</td>
<td>N</td>
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<tr>
<td>21</td>
<td>Reduced Parking Footprint</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>22</td>
<td>Green Vehicles</td>
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#### Sustainable Sites (10)

<table>
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<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>23</td>
<td>Construction Activity Pollution Prevention</td>
<td>Required</td>
<td>N</td>
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<tr>
<td>24</td>
<td>Site Assessment</td>
<td>Y</td>
<td>N</td>
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<tr>
<td>25</td>
<td>Site Development - Protect or Restore Habitat</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>26</td>
<td>Open Space</td>
<td>N</td>
<td>N</td>
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<tr>
<td>27</td>
<td>Rainwater Management</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>28</td>
<td>Heat Island Reduction</td>
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<td>Y</td>
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<tr>
<td>29</td>
<td>Light Pollution Reduction</td>
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#### Water Efficiency (11)

<table>
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<tr>
<td>30</td>
<td>Outdoor Water Use Reduction</td>
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<td>31</td>
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<tr>
<td>32</td>
<td>Building-Level Water Metering</td>
<td>Y</td>
<td>N</td>
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<tr>
<td>33</td>
<td>Outdoor Water Use Reduction</td>
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<tr>
<td>34</td>
<td>Indoor Water Use Reduction</td>
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<td>35</td>
<td>Cisterns for Water Use</td>
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<td>36</td>
<td>Water Metering</td>
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#### Energy and Atmosphere (33)

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<th>Description</th>
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<tr>
<td>37</td>
<td>Fundamental Commissioning and Verification</td>
<td>Required</td>
<td>N</td>
</tr>
<tr>
<td>38</td>
<td>Minimum Energy Performance</td>
<td>Required</td>
<td>N</td>
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<tr>
<td>39</td>
<td>Building-Level Energy Metering</td>
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<tr>
<td>40</td>
<td>Functional Refrigerant Management</td>
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<td>41</td>
<td>Enhanced Commissioning</td>
<td>N</td>
<td>Y</td>
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<tr>
<td>42</td>
<td>Efficiency</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>43</td>
<td>Demand Response</td>
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<td>Y</td>
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<td>Renewable Energy Production</td>
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<td>Y</td>
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<tr>
<td>45</td>
<td>Enhanced Refrigerant Management</td>
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<tr>
<td>46</td>
<td>Green Power and Carbon Credits</td>
<td>N</td>
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#### Materials and Resources (13)

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<tr>
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<th>N</th>
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<tr>
<td>47</td>
<td>Storage and Collection of Recyclables</td>
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<tr>
<td>48</td>
<td>Construction and Demolition Waste Management Planning</td>
<td>Required</td>
<td>N</td>
</tr>
<tr>
<td>49</td>
<td>Building Life-Cycle Impact Reduction</td>
<td>Required</td>
<td>N</td>
</tr>
<tr>
<td>50</td>
<td>Building Product Disclosure and Optimization - Environmental Product Declarations</td>
<td>Required</td>
<td>N</td>
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<tr>
<td>51</td>
<td>Building Product Disclosure and Optimization - Sourcing of Raw Materials</td>
<td>Required</td>
<td>N</td>
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<td>52</td>
<td>Building Product Disclosure and Optimization - Material Ingredients</td>
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<tr>
<td>53</td>
<td>Construction and Demolition Waste Management</td>
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#### Indoor Environmental Quality (16)

<table>
<thead>
<tr>
<th>Credit</th>
<th>Description</th>
<th>Y</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Minimum Indoor Air Quality Performance</td>
<td>Required</td>
<td>N</td>
</tr>
<tr>
<td>55</td>
<td>Environmental Tobacco Smoke Control</td>
<td>Required</td>
<td>N</td>
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<tr>
<td>56</td>
<td>Enhanced Indoor Air Quality Strategies</td>
<td>Required</td>
<td>N</td>
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<tr>
<td>57</td>
<td>Low-Emitting Materials</td>
<td>Required</td>
<td>N</td>
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<tr>
<td>58</td>
<td>Construction Indoor Air Quality Management Plan</td>
<td>Required</td>
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<tr>
<td>59</td>
<td>Indoor Air Quality Assessment</td>
<td>Required</td>
<td>N</td>
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<td>60</td>
<td>Thermal Comfort</td>
<td>Required</td>
<td>N</td>
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<td>61</td>
<td>Interior Lighting</td>
<td>Required</td>
<td>N</td>
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<td>62</td>
<td>Daylight</td>
<td>Required</td>
<td>N</td>
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<td>63</td>
<td>Quality Views</td>
<td>Required</td>
<td>N</td>
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<td>64</td>
<td>Acoustical Performance</td>
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#### Innovation (6)

<table>
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<tbody>
<tr>
<td>65</td>
<td>Innovation</td>
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<tr>
<td>66</td>
<td>LEED Accredited Professional</td>
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#### Regional Priority (4)

<table>
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<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>67</td>
<td>Regional Priority - Specific Credit 1</td>
<td>Required</td>
<td>N</td>
</tr>
<tr>
<td>68</td>
<td>Regional Priority - Specific Credit 2</td>
<td>Required</td>
<td>N</td>
</tr>
<tr>
<td>69</td>
<td>Regional Priority - Specific Credit 3</td>
<td>Required</td>
<td>N</td>
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<tr>
<td>70</td>
<td>Regional Priority - Specific Credit 4</td>
<td>Required</td>
<td>N</td>
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</tbody>
</table>

### Totals

**Possible Points: 110**

Certified: 61 to 69 points. Silver: 70 to 79 points. Gold: 80 to 99 points. Platinum: 100 to 110
LEED Certification

LEED BD+C: New Construction v3 - LEED 2009
New Offices

LEED Scorecard

- Sustainable Sites: 13 of 26
- Water Efficiency: 8 of 16
- Energy & Atmosphere: 20 of 35
- Material & Resources: 3 of 14
- Indoor Environmental Quality: 7 of 15
- Innovation: 6 of 6
- Regional Priority Credits: 4 of 4
- Integrative Process Credits: 0 of 3

LEED Facts

- Certification in progress: Gold 61/110
- Sustainable sites: 13 of 26
- Water efficiency: 8 of 16
- Energy & atmosphere: 20 of 35
- Material & resources: 3 of 14
- Indoor environmental quality: 7 of 15
- Innovation: 6 of 6
- Regional priority credits: 4 of 4
- Integrative process credits: 0 of 3
<table>
<thead>
<tr>
<th>LEED Rating Level</th>
<th>Points Earned</th>
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<tbody>
<tr>
<td>Certified</td>
<td>40-49 points earned</td>
</tr>
<tr>
<td>Silver</td>
<td>50-59 points earned</td>
</tr>
<tr>
<td>Gold</td>
<td>60-79 points earned</td>
</tr>
<tr>
<td>Platinum</td>
<td>80+ points earned</td>
</tr>
</tbody>
</table>
BIM & LEED intersection

BIM & LEED intersection

Efficiency
Quality
Sustainability
BIM & LEED intersection

RESEARCH

AEC INDUSTRY

SOFTWARE INDUSTRY
A study covering 1500 papers published over the past 25 years by BIM researchers from 65 countries.

Cb Amarnath (2016). “Global trends in BIM research” BIMe Initiative
Building information modeling for sustainable design and LEED® rating analysis

September 2012: Wei Wu, R.R.A Issa
Leveraging cloud-bim for leed automation

January 2015: Wei Wu, R.R.A Issa
BIM Execution Planning in Green Building Projects: LEED as a Use Case

May 2015: F. Jalaei, A. Jrade
Integrating building information modeling (BIM) and LEED system at the conceptual design stage of sustainable buildings
BIM & LEED intersection: AEC INDUSTRY

PROJECTS
BIM & LEED intersection: AEC INDUSTRY

USA
Turner Construction: 139 LEED-BIM projects

EUROPE
LEED Gold 2017: Manifattura Bulgari, Valenza (AL), and many more...
BIM & LEED intersection: SOFTWARE INDUSTRY

**November 2006:** Autodesk and U.S. Green Building Council Partner on Technology Initiatives to Move Building Industry toward Greener Future

**September 2014:** Revit Credit Manager for LEED plug-in developed by Autodesk Lab

**July 2011:** AECOsim Energy Simulator built into the Bentley Microstation quickly run simulations that generate documentation and reports that are ASHRAE Standard 90.1 compliant and LEED certified.

**February 2017:** IES-VE Navigator for LEED V4

**August 2017:** Which LEED credits does DesignBuilder calculate?
Under Energy & Atmosphere (EA):
- Minimum Energy Performance prerequisite 2 (required)
- Optimize Energy Performance credit 1

Under Indoor Environmental Quality (EQ):
- Minimum Indoor Air Quality prerequisite 1 (required)
- Increased Ventilation EQ credit 2
- Daylight & Views: Daylight EQ credit 8.1
BIM & LEED intersection

RESEARCH

AUTOMATION OF LEED CREDIT CALCULATION

AEC INDUSTRY

SOFTWARE INDUSTRY
NOT YET COMPLETELY AUTOMATED
The only way is interoperability
Interoperability Issues

“We have found that 50% of the time it takes to build and analyze an energy model is spent simply re-creating the building geometry in a new application.”

April 2008: Eddy Krygiel, Brad Nies, Steve McDowell
Green BIM: Successful Sustainable Design with Building Information Modeling
Interoperability Issues

TRANSLATOR

CLOSED BIM
SAME SOFTWARE HOUSE

OPEN BIM
DIFFERENT SOFTWARE HOUSE
Interoperability Issues

- **REVIT**
- **ARCHICAD**
- **OPENBUILDINGS**

**BIM4LEED**

-[CLOSED] BIM

**BI-DIRECTIONAL**

- **INSIGHT 360**
- **ECODESIGNER**
- **AECOSIM ENERGY SIMULATOR & HEVACOMP**
Interoperability Issues

BIM

ANALYSIS TOOL

HARDLY BI-DIRECTIONAL

OPEN BIM™
Interoperability Issues

Credit to Simone Viani (2015),
tratto dalla tesi di laurea “BIM per il retrofitting energetico ed impiantistico in edifice storici”.
University of Bologna
Interoperability Issues
Interoperability Issues: a BIM ‘round trip’

such that $A_1 = A_2$, for any model $A_1$

*(the ‘Sacks Test’)*
Interoperability Issues

OPEN BIM™ + VISUAL SCRIPTING

BIM

ANALYSIS TOOL

MAYBE
BI-DIRECTIONAL

Rajiv R.
ANALYSIS TOOL

DesignBuilder

X

etas

IES

eQUEST

EDSL

Tas

gbXML

Dxf

Rhinoceros

speckle

works

Topologic

Sustainable Places
The only way for total automation
How many LEED credits can we automate with a BIM process?

How many LEED credits can we automate with a BIM process?

- **81%**: 13 out of 16 available points
- **30%**: 3 out of 10 available points
- **72%**: 8 out of 11 available points
- **66%**: 22 out of 33 available points
- **63%**: 7 out of 13 available points
- **43%**: 6 out of 16 available points

Percentage of LEED credits that the Lombardini22 can verify in a BIM process. Credit to A. Meneghelli, R. Cerda, G. Faccio, G. Drudi of Lombardini22
How many LEED credits can we automate with a BIM process?

Percentage of LEED credits that the Lombardini22 can verify in a BIM process.

Credit to A. Meneghelli, R. Cerda, G. Faccio, G. Drudi of Lombardini22
BIM4LEED Matrix tool

an objective value of much is suitable the BIM process for the specific LEED project

<table>
<thead>
<tr>
<th>LEED v4 for BD+C: New Construction and Major Renovation</th>
<th>N° Credits</th>
<th>BIM4LEED RATING DONE</th>
<th>BIM4LEED RATING HYPO</th>
<th>Workflow Notes</th>
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<tbody>
<tr>
<td>Indoor Environmental Quality</td>
<td>16</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>41 Prereq Minimum Indoor Air Quality Performance</td>
<td>Required</td>
<td>Option 1. ASHRAE Standard 62.1–2010</td>
<td>3</td>
<td>Revit - Dynamo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Option 2. CEN Standards EN 15511–2007 and EN 13779–2007</td>
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<td></td>
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<tr>
<td>42 Prereq Environmental Tobacco Smoke Control</td>
<td>Required</td>
<td>Option 1. No smoking (Residential Only)</td>
<td>3</td>
<td>Revit - Dynamo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Option 2. Commercialization of smoking areas</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>43 Credit Enhanced Indoor Air Quality Strategies</td>
<td>2</td>
<td>Option 1. Enhanced IAQ strategies</td>
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<td></td>
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<td></td>
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<td>Option 2. Additional Enhanced IAQ Strategies</td>
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<td>44 Credit Low-Emitting Materials</td>
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<tr>
<td>45 Credit Construction Indoor Air Quality Management Plan</td>
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<tr>
<td>46 Credit Indoor Air Quality Assessment</td>
<td>2</td>
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<tr>
<td>47 Credit Thermal Comfort</td>
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<tr>
<td>48 Credit Interior Lighting</td>
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<tr>
<td>49 Credit Daylight</td>
<td>3</td>
<td>Option 1. Simulation—Spatial Daylight Autonomy</td>
<td>5</td>
<td>Revit - Plug in: Daylight Insight 300</td>
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<td></td>
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<td>Option 2. Simulation—Illuminance Calculations</td>
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<td>Option 3. Measurement</td>
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<td>50 Credit Quality Views</td>
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<td>2</td>
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</tr>
<tr>
<td>51 Credit Acoustic Performance</td>
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</table>
an objective value of much is suitable the BIM process for the specific LEED credit
0.

You can’t verify it in the BIM Authoring Tool

BIM4LEED Rating: 0
1. You must export the model in IFC or gbXML to verify it
Energy and Atmosphere
Optimize Energy Performance

Requirements
Option 1. Whole-building energy simulation (1–18 points)
Demonstrate an improvement more than 6% for new construction in the proposed building performance rating compared with baseline building performance rating.

Calculation Method
\[
\frac{(\text{Baseline building performance} - \text{Design building performance})}{\text{Baseline building performance}} > 6\%
\]
Energy Model

Aims to analyze building design configuration and heating and cooling load reduction strategies
Optimize Energy Performance
Export design info in gbXML

- Project information:
  - Location
  - Orientation
- Spaces information:
  - Geometry
  - Spaces Name
  - Space thermal template surfaces
  - Surface type
  - Materials thermal properties
  - Components thermal properties
  - Shading surfaces
Import design info with gbXML

- Project information:
  - Location
  - Orientation
- Spaces information:
  - Geometry
  - Spaces Name
  - Space thermal template surfaces
  - Surface type
  - Materials thermal properties
  - Components thermal properties
  - Shading surfaces
Model potential HVAC proposed system type
Energy Simulation with IES VE
Results and interpretation of Energy Simulation with IES VE

Consumption Report

- Baseline
- Proposed
Whole-Building Energy Simulation
Demonstrate an improvement more than 20% for new construction in the proposed building performance rating compared with baseline.
You can use the BIM Authoring Tool "like CAD" to verify it.
Promoteia
Client: Prometeia spa
Type: Headquarter
Site: Bologna, Italy
Area: 50,000 sqm
Year: 2017-2019

FEASIBILITY STUDY
PRELIMINARY DESIGN
URBAN PLAN IMPLEMENTATION
ARCHITECTURAL EXECUTIVE DESIGN
STRUCTURAL EXECUTIVE DESIGN
Indoor Environmental Quality

Prerequisite: Environmental Tobacco Smoke Control

Requirements
Prohibit smoking inside the building.
Prohibit smoking outside the building except in designated smoking areas located at least 7.5 meters from all entries, outdoor air intakes, and operable windows.
Environmental Tobacco Smoke Control Workflow

- Create a new Revit view for the ground floor
- Create annotation families for
  - Signage for no smoking area
  - Signage for designated smoking area
  - Signage for no smoking area outside the property line
Environmental Tobacco Smoke Control Workflow

- Design circumferences with 7.5 m radius and the centre at the entrance
- Put signage of no smoking areas outside the circumferences
BIM4LEED Rating: 3

You can use the BIM Authoring Tool + Visual Scripting Tool to verify it
Materials and Resources
Building Life-Cycle Impact Reduction

Option 4. Whole Building Life Cycle Assessment

Requirements

Demonstrate reduced environmental effects during initial project decision-making
How can I calculate LCA?
1. Development of the **BIM Model** through Revit: the external opaque envelope (thus excluding windows) of a multi-storey student residence model floorplan

How can I calculate LCA?
How can I calculate LCA?

4. Association of the new parameters to the BIM model’s materials
How can I calculate LCA?

5. LCA data collection and development of a spreadsheet containing environmental data about walls materials
- Codifying and Classifying walls materials
- Listing the selected environmental impacts for each of the LifeCycle phases considered
How can I calculate LCA?

6. Implementation of the Dynamo script to import the spreadsheet data into the BIM model:

- Selection of just those materials to which allocate (environmental impacts) values taken from the spreadsheet.
- Data mining operations.
- Data allocation to materials parameters.
- Creation of lists of (environmental impacts) values sorted per impact category and life cycle stage.
- Allocation of the (environmental impacts) values to materials parameters (identified by the name).
- Selection of just those non-null (environmental impacts) values to allocate to Revit model's materials.
- Allocation of spreadsheet (non-null) names to Revit model's materials.
- Creation of a list containing materials' names and removal of null cells (headings etc).
- Data mining from the spreadsheet.
- Creation of new materials in the Revit model according to spreadsheet materials column.
How can I calculate LCA?

Script execution effect on the BIM model
How can I calculate LCA?

8. Creation of custom Schedules in order to visualize the actual environmental impacts of each materials or aggregation of components (walls)
BIM4LEED Rating: 4

You can use the BIM Authoring Tool basic commands to verify it
Material and Resources
Building life-Cycle Impact Reduction

Requirements
Option 3: Building and material Reuse (BD+C 2-4 pt)
Reuse or salvage building materials from off site or on site as a percentage of the surface area. Include structural elements, enclosure materials and interior elements.

<table>
<thead>
<tr>
<th>Percentage of completed project surface area reused</th>
<th>Points BD+C</th>
<th>Points BD+C (Core and Shell)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>50%</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>75%</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Workflow

• Create a Revit model with
  – structural elements (e.g., floors, roof decking)
  – enclosure materials (e.g., skin, framing)
  – permanently installed interior elements (e.g., walls, doors, floor coverings, ceiling systems)
Building life-Cycle Impact Reduction

- Set phases and discipline in the Revit model
Building life-Cycle Impact Reduction

- Existing and reused area of structural column must be calculated on both sides: create schedules with calculated value “Area*2”
Take the total from the schedules and put it in a spreadsheet that calculates the percentage of Reused Area.

**Building life-Cycle Impact Reduction**

**Revit Schedules**

<table>
<thead>
<tr>
<th>Element Description</th>
<th>Existing Area (sq m)</th>
<th>Reused or Salvaged Area (sq m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural roof deck</td>
<td>1,760</td>
<td>1,582</td>
</tr>
<tr>
<td>Finished ceiling</td>
<td>5,035</td>
<td>0</td>
</tr>
<tr>
<td>Interior floor finish</td>
<td>11,610</td>
<td>3,836</td>
</tr>
<tr>
<td>Exterior enclosure (excluding windows)</td>
<td>6,910</td>
<td>6,910</td>
</tr>
<tr>
<td>Interior wall partition (both sides)</td>
<td>4,831.57</td>
<td>1,473.54 +</td>
</tr>
<tr>
<td>Structural columns</td>
<td>2,992</td>
<td>2,992 +</td>
</tr>
<tr>
<td>Interior structural wall</td>
<td>8,220</td>
<td>8,220 +</td>
</tr>
<tr>
<td>Foundation</td>
<td>806</td>
<td>806 +</td>
</tr>
<tr>
<td>Structural floor deck</td>
<td>11,534</td>
<td>11,534 +</td>
</tr>
<tr>
<td><strong>Total area (sq m)</strong></td>
<td><strong>53,698.57</strong></td>
<td>37,353.54 +</td>
</tr>
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</table>

**Percent building reuse (%)**

69.56%

**TABLE 1. Points for reuse of building materials**

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You can use the BIM Authoring Tool with specific LEED plug-in to verify it.
Option 1: Simulation: Spatial Daylight Autonomy and Annual Sunlight Exposure

Requirements
Provide manual or automatic (with manual override) glare-control devices for all regularly occupied spaces.
What does LEED ask for?

- **Where**: regularly occupied floor area (%), at 76.2 cm (30 in) above the finished floor

- **When**: between 8:00 a.m. and 6:00 p.m., over an entire calendar year

- **What**: Spatial Daylight Autonomy (sDA) > 55% or >75% and, Annual Sunlight Exposure (ASE) < 20%
How can I calculate sDA and ASE?

Autodesk Revit → Autodesk Insight 360 → Lighting Module
How can I calculate sDA and ASE?

**Project INFORMATION**
- Project location
  - Real North
  - Room setting

**GLAZING materials**
- Colour
  - Thickness*

**OPAQUE materials**
- Colour
  - *no more from Lighting v4.0+
How can I calculate sDA and ASE?

Analysis output → Plan view
How can I calculate sDA and ASE?
structure the BIM data to insert them automatically in the LEED Online Spreadsheet
Currently

All the previous methodology was under BIM level 2 maturity level
The future of interoperability

Cloud BIM
The future

But the industry now is moving to BIM Level 3 which will ease/automate the integration between BIM and sustainability certifications.
Ontologies & Semantic web

Use case requirements

BIM4LEED
Ontologies & Semantic web

Use case requirements

Ontology Development

Existing ontologies + Developed Modular ontologies + Enrichments
Ontologies & Semantic web

Use case requirements

Ontology Development

Existing ontologies + Developed Modular ontologies + Enrichments

Ontology Harmonization

Alignment + Evaluation
Reasons to develop an ontology

- Create a common understanding of information among people
- Enable reuse of domain knowledge
- Make a domain’s main assumptions explicit
- Separate domain knowledge from the operation knowledge
- Analyze domain knowledge
iGBR framework - Example

Source: (Zhang D., et. 2019)
iGBR framework - Example

Semantic Knowledge Representation

- Green Building Rating standard
- Knowledge Analysis
- Knowledge suitable for iGBR
- Ontological Engineering
- iGBR Ontology

BIM-based Building Design

- BIM model in Cloud
- BIM Authoring
- Communication
- Design team
- Stakeholders

Source: (Zhang D., et. 2019)
iGBR framework - Example

Semantic Knowledge Representation
- Knowledge Analysis
  - Green Building Rating standard
- Ontological Engineering
  - Knowledge suitable for iGBR
- iGBR Ontology

BIM-based Building Design
- Communication
  - Stakeholders
  - Feedback
  - BIM model in Cloud
  - Design team

Rule-based Reasoning
- SWRL (Semantic Web Rule Language)
  - Input
  - SWRL Rules
  - Jess Reasoning Engine
  - Green building Design Data

Source: (Zhang D., et. 2019)
ifcOWL: Web Ontology Language

Using the ifcOWL ontology, one can represent building data using state of the art web technologies (semantic web and linked data technologies).
Thank you