

Assessing buildings compliance with sustainability rating systems through a BIMbased approach

Paper session: Renovation



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The team



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D SUSTAINABLE PLACES

Presentation structure



- Green BIM state of the art
- BIM & LEED Intersection
- How many LEED credits can we automate with a BIM process?
- BIM4LEED Matrix

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- 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?



Rating systems

BD+C	
BUILDING DESIGN	INTERI
New Construction	Comme
Core & Shell Schools	Retail
Retail	nospra
do altheore	

Data Centres Hospitality Warehouses & Distribution

PERATION **Existing Buildings** Data Centres Warehouses & Distribution Hospitality

Schools

Retail

EIGHBOURHOOD EVELOPMENT New land developments Land Redevelopment Residential Mixed Use Commercial Industrial

HOMES

Single Homes Low Rise Multi Unit Mid Rise Multi Unit

Credit Categories

constrained sites

Each rating system is made up of a combination of credit categories.

UCTION

ical Interiors

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.



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INTEGRATIVE PROCESS TRANSPORTATION Encouraging cross discipline collaboration Access to variety of transport and/or credit for

. . LOCATION &

WATER EFFICIENCY Using sustainable materials Smart use and reuse of water

ENERGY & ATMOSPHERE Energy Performance

SUSTAINABLE SITES Minimising impact on ecosystems & water resources

INDOOR ENVIRONMENT

REGIONAL PRIORITY Geographic environmental priorties

Indoor air quality & access to natural light & views









LEED Credits

× 2		Proje	Ct Checklist		Pro	ject te:	Nar	ne:	
		Credit	Integrative Process	1					
8 0	0 0	Locat	ion and Transportation	* 16	0	0	0	Mater	rials and Resources
6		Credit	LEED for Neighborhood Development Location	16	Y	-	1	Prereq	Storage and Collection of Recyclables
1		Credit	Sensitive Land Protection	1	Y	1		Prereg	Construction and Demolition Waste Management Planning
1		Credit	High Priority Site	2			1	Credit	Building Life-Cycle Impact Reduction
		Credit	Surrounding Density and Diverse Uses	5				Credit	Building Product Disclosure and Optimization - Environmental Product Declarations
		Credit	Access to Quality Transit	5				Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials
		Credit	Bicycle Facilities	1			1	Credit	Building Product Disclosure and Optimization - Material Ingredients
		Credit	Reduced Parking Footprint	1				Credit	Construction and Demolition Waste Management
-		Credit	Green Vehicles	1		-	-		
	-				0	0	0	Indoc	or Environmental Quality
0	0 0	Susta	inable Sites	10	Y		-	Prereq	Minimum Indoor Air Quality Performance
		Prereg	Construction Activity Pollution Prevention	Required	Y	1		Prereg	Environmental Tobacco Smoke Control
	1	Credit	Site Assessment	1	-			Credit	Enhanced Indoor Air Quality Strategies
-		Credit	Site Development - Protect or Restore Habitat	2	-	-		Credit	Low-Emitting Materials
-		Credit	Open Space	1	-		-	Credit	Construction Indoor Air Quality Management Plan
-		Credit	Rainwater Management	3		-	-	Credit	Indoor Air Quality Assessment
-		Credit	Heat Island Reduction	2	-		-	Credit	Thermal Comfort
-		Credit	Light Pollution Reduction	-	-	-	-	Credit	Interior Lighting
-		1				-		Credit	Daviaht
70	170	Water	Efficiency			-	-	Creft	Ouglity Viewe
		Prereo	Outdoor Water Use Reduction	Required		-	-	Credit	Acoustic Performance
		Preneo	Indoor Water Lise Reduction	Required	land in	-	1		
		Presen	Building I wai Water Metering	Required	20	10	0	Innos	ration
21		Condit	Outring-Cover Visite Instanting	2				Credit	Innovation
-		Credit	Indoor Water Lise Reduction	6	_	-	-	Credit	LEED According Professional
-		Crade	Cooling Towner Water Line	2	h		1	o o o o	
-	-	Castle	Water Metering	2	20	10	10	Doni	anal Priority
	10000	- der	The second se	83				Cast	Regional Brinch: Specific Credit
10	10	Energ	wand Atmoenhere	22		-	-	Cedit	Regional Printly: Specific Credit
		Preses	Fundamental Commissioning and Varification	Required		-	-	Credit	Regional Priority: Specific Credit
,		Presen	Minimum Energy Deformance	Required	-	-	-	Credit	Regional Printly, Specific Credit
-		Present	Building I and Energy Metering	Required	1. Contract 1. Con			S.C.M.	ragement meny. Operate street
-		Presso	Eundamental Refrigerent Management	Required	240	Fo	10	TOTA	Dossible B
22	1000	Conte	Enhanced Commissioning	Required	10	0	0	Con	HEad: 40 to 40 points Silvers 50 to 50 points Cald: 60 to 70 points Bistianum 90 to
		Cande	Ontimize Energy Beformance	18				Gen	anea, to to to to points, anten, or to or points, aoid; or to ra points, Platinum; or t
-		Canda	Advanced Energy Metering	10					
		Candi	Demand Response	2					
-	-	Candi	Peneuroble Energy Destruction	4					
		Contra	Fahrenard Befriesset Management	3					
		0.000	Enhanced Reingerant Management	1					
		A REAL PROPERTY AND ADDRESS OF ADDRESS OF ADDRESS ADDRES	Langer Priver and Carrier Conserve						

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Required

Required

Required Required

Possible Points:

LEED Certification

	LEED BD+C: New Construction v3 - LEED 2009 New Offices
	United Kingdom ♥ Map
Overview	d Stories

LEED Scorecard	Gold 61/110	 E Share on Twitter f Share on Facebook in Share on LinkedIn ➡ Print 	
▶ SUSTAINABLE SITES	13 OF 26		
WATER EFFICIENCY	8 OF 10	LEED Facts for LEED BD+C: New Constru (v2009)	ction
ENERGY & ATMOSPHERE	20 OF 35	Certification in progress	61
MATERIAL & RESOURCES	3 OF 14	Sustainable sites	13/26
INDOOR ENVIRONMENTAL QUALITY	7 OF 15	Water efficiency Energy & atmosphere	8/10 20/35
	6 OF 6	Indoor environmental quality	3/14 7/15 6/6
► REGIONAL PRIORITY CREDITS	4 OF 4	Regional priority credits Integrative process credits	4/4
► INTEGRATIVE PROCESS CREDITS	0 OF 3		

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LEED Rating Levels





Certified

40-49 points earned

Silver

50-59 points earned



Gold

60-79 points earned



Platinum

80+ points earned



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BIM & LEED intersection: RESEARCH RESEARCH PAPERS



SUSTAINABLE PLACES 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

BIM & LEED intersection: RESEARCH



TAXABLE IN ACCOUNTS A REPORT OF **AUTOMATION IN** ONSTRUCTION AN INTERNATIONAL RESEARCH JOURNAL IDSTEA IN CASE M.S. CERNICHLED This way of the party of Design & Engineering Construction Technology Maintenance & Management www.elsevier.com/locate.testico

March 2011: Salman Azhar, Wade A. Carlton, Darren Olsen, Irtishad Ahmad 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

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Turner Construction: 139 LEED-BIM projects



EUROPE

LEED Gold 2017: Manifattura Bulgari, Valenza (AL), and many more...





BIM & LEED intersection: SOFTWARE INDUSTRY





November 2006: <u>Autodesk and U.S. Green Building Council Partner on Technology Initiatives to Move Building</u> <u>Industry toward Greener Future</u> September 2014: <u>Revit Credit Manager for LEED</u> plug-in developed by Autodesk Lab



July 2011: <u>AECOsim Energy Simulator</u> 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

Automated credit assessments across Daylighting, Thermal Comfort, Water, Renewables, Alternative Transport, Parking, Open Spaces, Storm Water, Heat Island, Water Efficiency landscaping, Controllability of Systems & Views.



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



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NOT YET COMPLETELY AUTOMATED

NN

1

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0

The only way is interoperability





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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



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Interoperability Issues OPEN BIM[™]







Credit to Simone Viani (2015), tratto dalla tesi di laurea "BIM per il retrofitting energetico ed impiantistico in edifice storici". University of Bologna



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such that $\underline{A1} = \underline{A2}$, for any model A1

(the 'Sacks Test')

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

LEED [®] -NC credits that performance analysis	at can be earned using BIM-based s software	Can the LEED® credit be earned using BIM? (yes/no)	Performance analysis software that could be or was used2 VE/REVIT	Is the credit being attempted by Salisbury Building?	Was the credit validated in the case study? (yes/no)	
LEED credit	Credit description	LEED [®] points		useu: vE/iEvii		
Sustainable sites						
SSp1	Construction activity pollution prevention	Required	No		Yes	
SSc1	Site selection	1	Yes	Revit	Yes	
SSc2	Development density and community connectivity	1	No		Yes	
SSc3	Brownfield redevelopment	1	No		Yes	
SSC4.1	Public transportation access Ricycle storage and changing rooms	1	NO		Yes	
SSc4 3	Low-emitting and fuel-efficient vehicles	1	No		Yes	
SSc4.4	Parking capacity	1	No		Yes	
SSc5.1	Protect or restore habitat	1	No		No	
SSc5.2	Maximize open space	1	Yes		Yes	
SSc6.1	Stormwater quantity control	1	Yes	Revit	No	
SSc6.2	Stormwater quality control	1	No		No	
SSc7.1	Reduce heat island effect - nonroof	1	Yes	Revit	Yes	
SSc7.2	Reduce heat island effect – roof	1	Yes	Revit	Yes	
SSc8	Light pollution reduction	1	Yes		No	
Mater all simo						
When a set where the set of the s	Water officient landscaping	2	Vac	Powit	No	
WECT.1 and WECT.2	Inpovative wastewater technologies	2	Ves	VE	No	Vec
WEC3 1 and WEC3 2	Water use reduction	2	Yes	VE	Yes	Yes
Theose and Theose	Water also reduction	2	100	•2		
Energy and atmosphe	re					
EAp1	Fundamental building systems commissioning	Required	No		Yes	
EAp2	Minimum energy performance	Required	Yes	VE	Yes	Yes
EAp3	Fundamental refrigerant management	Required	No		Yes	
EAc1	Optimize energy performance	10	Yes	VE	Yes	Yes
EAc2	Renewable energy	3	No		No	
EAc3	Enhanced commissioning	1	No		Yes	
EAc4	Enhanced refrigerant management	1	No		Yes	
EACS	Measurement and verification	1	NO		NO	
EACO	Green power	1	NO		NO	
Materials and resourc	es					
MRp1	Storage and collection of recyclables	Required	Yes	Revit	Yes	
MRc1.1 and MRc1.2	Building reuse – existing walls, floors and roof	2	Yes	Revit	No	
MRc1.3	Building reuse - existing interior nonstructural elements	1	Yes	Revit	No	
MRc2.1 and MRc2.2	Construction waste management	2	No		Yes	
MRc3.1 and MRC3.2	Materials reuse	2	No		No	
MRc4.1 and MRc4.2	Recycled content	2	Yes	Revit	Yes	
MRc5.1 and MRc5.2	Regional materials	2	Yes	Revit	Yes	
MRc6	Rapidly renewable materials	1	No	D. I.	No	
MRc7	Certified wood	1	Yes	Revit	Yes	
Indoor environmental	quality					
EOp1	Minimum indoor air quality (IAO) performance	required	No		Yes	
EQp2	Environmental tobacco smoke (ETS) control	required	No		Yes	
EOc1	Outdoor air delivering monitoring	1	No		Yes	
EQc2	Increase ventilation	1	No		No	
EQc3.1	Construction IAQ MGT plan — during construction	1	Yes	Revit	No	
EQc3.2	Construction IAQ MGT plan — before occupancy	1	Yes	Revit	No	
EQc4.1	Low-emitting materials — adhesives and sealants	1	No		Yes	
EQc4.2	Low-emitting materials — paints and coatings	1	No		Yes	
EQc4.3	Low-emitting materials – carpet systems	1	No		Yes	
EQc4.4	Low-emitting materials – composite wood and agrifiber	1	No		Yes	
EQC5	indoor chemical and pollutant source control	1	NO		Yes	
EQC6.1	Controllability of systems – lighting	1	NO		Yes	
EQ(0.2 E0-7.1	Thermal comfort decign	1	NO	VE	Tes	Voc
EQC/.1	Thermal comfort – design	1	No	VE.	Vac	105
FOr8 1	Davlight and views - davlight	1	Ves	VF	No	Ves
EQ:0.1	Daylight and views – views	1	Yes	VE	No	103
		-				
Innovation and design	process					
IDc1	Innovation in design	4	Yes	Revit, VE	Yes	
IDc2	LEED accredited professional	1	No		Yes	
-						

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Building information modeling for sustainable design and LEED rating analysis. (2010) Salman Azhar, Wade A. Carlton, Darren Olsen, Irtishad Ahmad

BIM4LEED

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

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

		81%	\mathbf{Y}		30%			72%
Locatio	on and Transportation		Sustai	nable Sites		Water	Efficiency	
Credit	LEED for Neighborhood Development Location	16	Prereq	Construction Activity Pollution Prevention	Required	Prereq	Outdoor Water Use Reduction	Required
Credit	Sensitive Land Protection	1	Credit	Site Assessment	1	Prerea	Indoor Water Use Reduction	Required
Credit	High Priority Site	2	Credit	Site Development - Protect or Restore Habitat	2	Floreq		rtoquirou
redit	Surrounding Density and Diverse Uses	5	Credit	Open Space	1	Prereq	Building-Level Water Metering	Required
redit	Access to Quality Transit	5	Credit	Rainwater Management	3	Credit	Outdoor Water Use Reduction	2
redit	Bicycle Facilities	1	Credit	Heat Island Reduction	2	Credit	Indoor Water Use Reduction	6
credit	Reduced Parking Footprint	1	Credit	Light Pollution Reduction	1	Credit	Cooling Tower Water Use	2
Credit	Green Vehicles	1+1				Oneilit	Water Matering	
		66%			53%			37%
Energy	and Atmosphere	66%	Materia	als and Resources	53%		Environmental Quality	37%
Energy Prereg	and Atmosphere Fundamental Commissioning and Verification	66% Required	Materia	als and Resources	53%	Indoor	Environmental Quality	37% Required
Energy Prereq	and Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance	66% Required	Materia Prereq	als and Resources Storage and Collection of Recyclables	53% Required	Indoor Prereq Prereq	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control	37%
Energy Prereq Prereq Prereq	and Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering	66% Required Required Required	Materia Prereq Prereq	als and Resources Storage and Collection of Recyclables C&D Waste Management Planning	53% Required Required	Indoor Prereq Prereq Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies	37% Required Required 2
Energy Prereq Prereq Prereq Prereq	and Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering Fundamental Refrigerant Management	66% Required Required Required Required	Materia Prereq Prereq Credit	als and Resources Storage and Collection of Recyclables C&D Waste Management Planning Building Life-Cycle Impact Reduction	53% Required Required 5	Indoor Prereq Prereq Credit Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies Low-Emitting Materials	37% Required Required 2 3
Energy Prereq Prereq Prereq Prereq Credit	and Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering Fundamental Refrigerant Management Enhanced Commissioning	66% Required Required Required Required 6	Materia Prereq Prereq Credit Credit	als and Resources Storage and Collection of Recyclables C&D Waste Management Planning Building Life-Cycle Impact Reduction Building Product Optimization EPD	53% Required Required 5 2	Indoor Prereq Prereq Credit Credit Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies Low-Emitting Materials Construction Indoor Air Quality Management Plan	37% Required Required 3 n 1
Energy Prereq Prereq Prereq Prereq Prereq Credit Credit	A and Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering Fundamental Refrigerant Management Enhanced Commissioning Optimize Energy Performance	66% Required Required Required Required 6 18	Materia Prereq Prereq Credit Credit	Als and Resources Storage and Collection of Recyclables C&D Waste Management Planning Building Life-Cycle Impact Reduction Building Product Optimization EPD Sourcing of Raw Materials	53% Required Required 5 2 2 2	Indoor Prereq Prereq Credit Credit Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies Low-Emitting Materials Construction Indoor Air Quality Management Plan Indoor Air Quality Assessment Through Conferent	Required Required 2 3 1 2
Energy Prereq Prereq Prereq Prereq Credit Credit Credit	A and Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering Fundamental Refrigerant Management Enhanced Commissioning Optimize Energy Performance Advanced Energy Metering	66% Required Required Required Required 6 18	Materia Prereq Prereq Credit Credit Credit	Als and Resources Storage and Collection of Recyclables C&D Waste Management Planning Building Life-Cycle Impact Reduction Building Product Optimization EPD Sourcing of Raw Materials Material Ingredients Construction and Description Works Material	53% Required Required 5 2 2 2 2 2	Indoor Prereq Prereq Credit Credit Credit Credit Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies Low-Emitting Materials Construction Indoor Air Quality Management Plan Indoor Air Quality Assessment Thermal Comfort Interior Linthing	Required Required 2 3 1 2 1 2
Energy Prereq Prereq Prereq Prereq Credit Credit Credit	A and Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering Fundamental Refrigerant Management Enhanced Commissioning Optimize Energy Performance Advanced Energy Metering Demand Response	66% Required Required Required 6 18 1 2	Materia Prereq Prereq Credit Credit Credit Credit	Als and Resources Storage and Collection of Recyclables C&D Waste Management Planning Building Life-Cycle Inpact Reduction Building Product Optimization EPD Sourcing of Raw Materials Material Ingredients Construction and Demolition Waste Management	53% Required Required 5 2 2 2 2 2 2 2 2 2	Indoor Prereq Prereq Credit Credit Credit Credit Credit Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies Low-Emiting Materials Construction Indoor Air Quality Management Plan Indoor Air Quality Assessment Thermal Comfort Interior Lighting Davlight	Required Required 2 3 1 2 1 2 3+1
Energy Prereq Prereq Prereq Credit Credit Credit Credit	And Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering Fundamental Refrigerant Management Enhanced Commissioning Optimize Energy Performance Advanced Energy Metering Demand Response Renewable Energy Production	66% Required Required Required 6 18 1 2 3	Materia Prereq Prereq Credit Credit Credit Credit Credit	Als and Resources Storage and Collection of Recyclables C&D Waste Management Planning Building Life-Cycle Impact Reduction Building Product Optimization EPD Sourcing of Raw Materials Material Ingredients Construction and Demolition Waste Management	53% Required Required 2 2 2 2 2 2 2	Indoor Prereq Prereq Credit Credit Credit Credit Credit Credit Credit Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies Low-Emitting Materials Construction Indoor Air Quality Management Plan Indoor Air Quality Assessment Thermal Comfort Interior Lighting Daylight Quality Views	37% Required Required 2 3 1 2 3+1 1
Prereq Prereq Prereq Prereq Credit Credit Credit Credit Credit	And Atmosphere Fundamental Commissioning and Verification Minimum Energy Performance Building-Level Energy Metering Fundamental Refrigerant Management Enhanced Commissioning Optimize Energy Performance Advanced Energy Metering Demand Response Renewable Energy Production Enhanced Refrigerant Management	66% Required Required Required 6 18 1 2 3 1	Materia Prereq Prereq Credit Credit Credit Credit	Als and Resources Storage and Collection of Recyclables C&D Waste Management Planning Building Life-Cycle Impact Reduction Building Product Optimization EPD Sourcing of Raw Materials Material Ingredients Construction and Demolition Waste Management	53% Required Required 2 2 2 2 2 2	Indoor Prereq Prereq Credit Credit Credit Credit Credit Credit Credit Credit Credit	Environmental Quality Minimum Indoor Air Quality Performance Environmental Tobacco Smoke Control Enhanced Indoor Air Quality Strategies Low-Emitting Materials Construction Indoor Air Quality Management Plan Indoor Air Quality Assessment Thermal Comfort Interior Lighting Daylight Quality Views Acoustic Performance	Require Require Require 3 1 2 3+1 1 1



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

BIM4LFFD

BIM4LEED Matrix tool



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

	LEED v4 for BD+C	: New Construction and Major Renovation	N° Credits		BIM4LEED RATING DONE	BIM4LEED RATING HYPO	Workflow Notes
	Indoor Environme	ntal Quality	16				
/1	Prorog	Minimum Indoor Air Quality Performance	Pequired	Option 1. ASHRAE Standard 62.1–2010			
41	Prereq Minimum motion Air Quality Performance		Required	Option 2. CEN Standards EN 15251–2007 and EN 13779–2007	3		Revit - Dynamo
42	Prereg	Environmental Tobacco Smoke Control	Required	Option 1. No smoking (Residentioal Only)	-	2	
72	Therey		Required	Option 2. Compartmentalization of smoking areas	2		Revit
43	Credit	Enhanced Indoor Air Quality Strategies	2	Option 1. Enhanced IAQ strategies	2		Revit
10	orodit		2	Option 2. Additional Enhanced IAQ Strategies	-		
44	Credit	Low-Emitting Materials	3				
45	Credit	Construction Indoor Air Quality Management Plan	1				
46	Credit	Indoor Air Quality Assessment	2				
47	Credit	Thermal Comfort	1				
48	Credit	Interior Lighting	2				
				Option 1. Simulation—Spatial Daylight Autonomy	5	-	Revit - Plug-in: Daylight Insight 360
49	Credit	Daylight	3	Option 2. Simulation—Illuminance Calculations	-		
				Option 3. Measurement	-		
50	Credit	Quality Views	1		2	-	Revit
51	Credit	Acoustic Performance	1				

BIM4LEED Rating



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







BIM4LEED Rating: 0










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

(Baseline building performance - Design building performance)

> 6%

Baseline building performance

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Lombardini22

DESIGN THINKING





Aims to analyze building design configuration and heating and cooling load reduction strategies



Spaces Thermal Template

Engineering & Sustainability

Conference Meeting	unge/ Recreation	Plenum	Starway
Corridor&Trasportation	ice - Enclosed	Restrooms	Storage



Optimize Energy Performance

2 3





Engineering & Sustainability

tel/Conference Center - Conference/Meeting		Parameter	Value
active Storage idges Chambers - Courthouse		Energy Analysis	
boratory - Office		Area per Person	20,000 m ²
undry - Ironing and Sorting undry - Washing - Hospital/Healthcare		Sensible Heat Gain per person	73,27 W
rary - Audio Visual - Library-Audio Visual		Latent Heat Gain per person	58,61 W
ing Quarters - Dormitory		Lighting Load Density	11,90 W/m ²
ing Quarters - Hotel		Power Load Density	16,00 W/m ²
bby		Plenum Lighting Contribution	20,0000%
bby - Auditorium bby - Hotel		Occupancy Schedule	Common Office Occupancy -
bby - Motion Picture Theatre		Lighting Schedule	Office Lighting - 6 AM to 11 P
bby - Performing Arts Theatre		Power Schedule	Office Lighting - 6 AM to 11 P
bby - Post Office bby - Religious Buildings		Outdoor Air per Person	2,50 L/s
unge/Recreation		Outdoor Air per Area	0,30 L/(s-m ²)
Il Concourse Sales Area - Retail es Merchandising Sales Area - Retail		Air Changes per Hour	0,000000
edium/Bulky Material - Warehouse		Outdoor Air Method	by People and by Area
ronanising Sales Area - Retail iseum and Gallery - Storage - Museum and Gallery res Station - Hospital/Healthcare fice - Endosed fice - Open Plan fice Common Activity Areas - Inactive Storage	-		
m ,			

Properties		×
R		
Spaces (1)		lit Type
Return Airflow	Specified	11.
Specified Return Airflow	0,00 L/s	
Actual Return Airflow	0,00 L/s	
Specified Exhaust Airflow	0,00 L/s	******
Actual Exhaust Airflow	0,00 L/s	
Outdoor Airflow	28,20 L/s	
LEED_OA provided	33,63 L/s	n
Identity Data		*
Workset	03_Interior	
Number	1004	
Name	Office	
Room Number	1004	******
Room Name	Office	*****
Image		
Comments		
Edited by	a.meneghelli	177979 (Amount)
Design Option	Main Model	
Phasing		\$
Phase	L22_SDP	
Energy Analysis		\$
Zone	Default	
Plenum		
Occupiable		
сопацион туре	meated and cooled	
Space Type	Office - Enclosed	and the second sec
Construction Type	<building></building>	
People	Edit	
Electrical Loads	Edit	
Outdoor Air Information	From Space Type	
Outdoor Air per Person	2,50 L/s	
Outdoor Air per Area	0,30 L/(s·m²)	
Air Changes per Hour	0,000000	
Outdoor Air Method	by People and by Area	ALL
Calculated Heating Load	1114,22 W	
Design Heating Load	1114,22 W	and a later of
Calculated Cooling Load	2613,98 W	Contra la
Design Cooling Load	2613,98 W	



PLACES





Export design info in gbXML



- Project information:
 - Location
 - Orientation
- Spaces information:
 - Geometry
 - Spaces Name
 - Space thermal template surfaces
 - Surface type

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- 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 —

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- Materials thermal properties ____
- Components thermal properties
- Shading surfaces —









🐒 Minaylinde (MHIZI Clouds Zone derived) 🔤 -(2.85),31.527 🕑 Teda 👊 1/6e4

BIM4LFFD



Model potential HVAC proposed system type

/E - ApHVAC - 0000 - GB R01 - HVAC System : Proposed Edit: View Tools ApHVAC Components Controllers Sizin		S 2 MIN				_ ī ×	UTC .
		Aphvac •	J + 🖬 👘 🐼 🐼				
Applications	• 🗢 🖉 🕲 O 🔞 🕸 🕸 🖉 🖉 🖗 🕼	\$ 🛃 🖗 🥋 🔍 🗇 🧼 🐘 🗈 🗗	<u>n e e e i a e</u>	<u>6666</u>	- - - 		
IRAE 90.1-2010 – App. G PRM and = 🤽 🖶 🗅 🗉 🗉 🔲) 🖗 🗆 🖻 🕨 🕪 🔟 📈 🖊 보 🏹 =	- I C] L J + P R R	🛤 맥 맥 왕 왕 왕 🥬 🗉 🕱 🍰 왕 🔗 🌮	S & & & & & & & & & & & & & & & & & & &	_ 🏷 🍋 🥙 💷 🕺 😫 🖌		
System Schedules and Setpoints							A
∋ Baseline System							
Edit Current Baseline ?		Central	e Frigorifera				
 Generate Baseline HVAC systems for 90°, 180° and 270° estations 			ganna				
Improve Upon Bereline 2			55 55				
Edit Current Proposed							
Or Custom System ?			in				
Other Input Data							
Sizing Runs							
Room Load Calculations ?							
1) Room/Zone Loads and Sizing Reports							
Review/edit current Baseline systems							
System Load Calculations			U				
• Update Baseline fan sizing data ?] .							
D System Sizing reports							
Simulations 🗋							
Daylight Simulation						/	
PRM Simulation							
AC Components -							
HVAC Network							_
ia- ≋ Airside							
ia							
🗇 💐 Chilled water loops							1
WL000000 : One Electric Water-Cooled Chiller with				3 3 3			
WL000001 : One Electric Air-Cooled Chiller							
m S WI 000002 : Two Sequenced PL Chillers - COP Inclu							
WED00003 : Institutive coning mode model							
WI 000005 : Electric Water-Cooled Chiller with Water							
WL000006 : Centrale Frigorifera							
- A Hot water loops						/	
🚋 🖏 HS000000 : 2 Nat-Draft Boilers, Primary-only HW L							
👜 🇐 HS000001 : 1 Nat-Draft Boiler, Primary-only HW Lo							
👜 😳 HS000002 : 2 Forced-Draft Non-Cond Boilers, diff s							
10-140-F SWT (
iii-100 HS000015 : 3 Nat-Draft Boilers - sequenced, Primar							
Hout transfer loops							
HT00000 : Heat Transfer Loon - Cooling tower have							
mines in coord a mean mansion coop - cooling tower her							

PLACES

Lombardini22 L22 Engineering & Sustainability



Energy Simulation with IES VE

Airflew Unit: Us

Date/Time: 21/Mar 11:30





Air temperature: 1003 Open Office (p_0000 - GE R01 aps)
 Ecoling set point: 1003 Open Office (p_0000 - GE R01 aps)
 Dry-bub temperature: (MicnWEC fwrt)

gineering &



Date: Wed 21/Mar





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Results and interpretation of Energy Simulation with IES VE





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Consumption Report

BASELINE PROPOSED

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DESIGN THINKING



Documentation from Energy Simulation



TABLE 1. Points for pe	TABLE 1. Points for percentage improvement in energy performance								
New Construction	Major Renovation	Core and Shell	Points (except Schools, Healthcare)						
6%	4%	3%	1						
8%	6%	5%	2						
10%	8%	7%	3						
12%	10%	9%	4						
14%	12%	11%	5						
16%	14%	13%	6						
18%	16%	15%	7						
20%	18%	17%	8						
22%	20%	19%	9						
24%	22%	21%	10						
26%	24%	23%	11						
29%	27%	26%	12						
18%	16%	15%	7						
20%	18%	17%	8						
22%	20%	19%	9						
24%	22%	21%	10						
26%	24%	23%	n						
29%	27%	26%	12						
32%	30%	29%	13						
35%	33%	32%	14						
38%	36%	35%	15						
42%	40%	39%	16						
46%	44%	43%	17						
50%	48%	47%	18						

(Baseline building performance - Design building performance)

Baseline building performance

Whole-Building Energy Simulation Demonstrate an improvement **more than 20%** for new construction in the proposed building performance rating compared with baseline.







2 ____ 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 BIN 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







3 - You can use the BIM Authoring Tool + Visual Scripting Tool to verify it

SUSTAINABLE PLACES



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











 Development of the BIM Model through Revit: the external opaque envelope (thus excluding windows) of a multi-storey student residence model floorplan









4. Association of the new parameters to the **BIM model's materials**

The sustainable places



••• • 🕅 Materials Environmental Data.xls								
			LCA Modules (e.g. A1-A3)					
Material Name	Material Type	Other Info	LCA Indicator (e.g GWP)	LCA Indicator (e.g. ODP)	LCA Indicator (e.g AP)	Functional Unit	Service Life	Source
ID_Name	ID_Type	Info	Value/Unit	Value/Unit	Value/Unit	Value	Value	Reference
ID_Name	ID_Type	Info	Value/Unit	Value/Unit	Value/Unit	Value	Value	Reference
ID_Name	ID_Type	Info	Value/Unit	Value/Unit	Value/Unit	Value	Value	Reference
ID_Name	ID_Type	Info	Value/Unit	Value/Unit	Value/Unit	Value	Value	Reference

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

DEACES PLACES





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

D C SUSTAINABLE PLACES



How can I calculate LCA?



Script execution effect on the BIM model



	٦	$\Sigma \zeta$
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				-				
Α	В	С	D	E	F	G	Н	I
						Product Stage		
Comments	Material: Name	Material: Volume	GWP (A1-A2-A3)	ODP (A1-A2-A3)	EP (A1-A2-A3)	AP (A1-A2-A3)	POCP (A1-A2-A3)	PERE (A1-
WE.PS-10	0mm-JendyJoss75LRcg							
Envelope	MX-SubstructurePlastboard-RockWool50	13.49 m³	561.921868	0.000019	0.299692	3.746146	0.486999	786.69061
Envelope	PB-CalciumSilicate-Sheet	2.16 m ³	4089.07936	0.000022	1.063647	5.817202	0.357794	6717.77323
Envelope	PB-Plastboard-Sheet-AluminiumVaporBarrier	2.34 m³	71.758729	0.000013	0.033922	0.450123	0.038489	443.599418
		17.98 m³	4722.759958	0.000054	1.397261	10.013471	0.883282	7948.06326
WE.PS-12	0mm-JendyJoss							
Envelope	MX-SubstructurePlastboard-RockWool70	7.46 m³	500.7744	0.000017	0.26708	3.338496	0.434004	701.08416
Envelope	PB-CalciumSilicate-Sheet	0.83 m³	1571.821978	0.000009	0.408861	2.236104	0.137534	2582.27896
		8.29 m ³	2072.596378	0.000025	0.675941	5.5746	0.571539	3283.36312
WE.PS-17	4mm-JendyJossE150LR							
Envelope	MX-SubstructurePlastboard-RockWool70	19.17 m³	1286.18875	0.000043	0.685967	8.574592	1.114697	1800.6642
Envelope	PB-CalciumSilicate-Sheet	3.07 m ³	5813.376307	0.000032	1.51217	8.27022	0.50867	9550.54679
		22.24 m ³	7099.565057	0.000075	2.198137	16.844812	1.623367	11351.211
WE.PS-22	0mm-JendyJoss							
Envelope	MX-SubstructurePlastboard-RockWool70	7.21 m ³	483.479487	0.000016	0.257856	3.223197	0.419016	676.871282
Envelope	PB-CalciumSilicate-Sheet	0.42 m³	787.951907	0.000004	0.204961	1.120955	0.068946	1294.4924
		7.62 m ³	1271.431394	0.00002	0.462817	4.344152	0.487961	1971.3637
<								>

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

ANALYSIS





4 Solution Service A Ser

SUSTAINABLE PLACES



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 1. Points for reuse of building materials				
Percentage of completed project surface area reused	Points BD+C	Points BD+C (Core and Shell)		
25%	2	2		
50%	3	3		
75%	4	5		

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Building life-Cycle Impact Reduction



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



• Existing and reused area of structural column must be calculated on both sides: create schedules with calculated value "Area*2"





Revit Schedules

Building life-Cycle Impact Reduction



• Take the total from the schedules and put it in a spreadsheet that calculate the percentage of Reused Area

Element	Description	(sq m)	Salvaged Area (sq m)	
Structural roof deck	·	1,760	1,582	н
Finished ceiling	·	5,035	0	+
Interior floor finish	ſ	11,610	3,836	н
Exterior enclosure (excluding windows)	·	6,910	6,910	+
 Interior wall partition (both sides)	·	4,831.57	1,473.54	+
Stuctural columns	·	2,992	2,992	н
Interior structural wall	·	8,220	8,220	+
Foundation		806	806	+
Structural floor deck	1	11,534	11,534	+
Total area (sq m)		53,698.57	37,353.54	
Percent building reuse (%)			69.56	



Reused or

	TABLE 1. Points for reuse of building materials					
	Percentage of completed project surface area reused	Points BD+C	Points BD+C (Core and Shell)			
	25%	2	2			
2 DT	50%	3	3			
371	75%	4	5			







5 Since the BIM Authoring Tool with specific LEED plug-in to verify it





Indoor Environmental Quality Daylight

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?





How can I calculate sDA and ASE?



THE PLACES



How can I calculate sDA and ASE?

Analysis output → Plan view





PLACES PLACES


How can I calculate sDA and ASE?

Analysis output → Schedule

Lighting Analysis - Results Summary	?	\succ
Daylight Autonomy (sDA preview)		
For all Rooms included in Daylighting		
Jan 1 to Dec 31, 8:00 am to 6:00 pm (Both sDA and ASE must be met for Room	area to qu	ualify
sDA _{300/50} + ASE _{1000/250}	3 Po	ints
77% of Building area meets sDA % h in Rooms with <10% area above ASE	ours	
Detailed Summary:		
77% of Building area meets sDA % hours 0% of sDA Building area fails for Rooms >	ASE	
0% of Building area >ASE hours threshold	I	
95% of Rooms meet sDA >55% Room are	ea	
95% of Rooms meet sDA >75% Room are 0% of Rooms >ASE hours >10% Room ar	ea Tea	
	Design	Tips

Daylight Autonomy (sDA Preview) Results Summary: Via Guido Guinizelli, 17, 40137 Bologna BO, Italia

Building scores 3 LEED points with 76% Building area passing thresholds

At least 55% must exceed sDA300/50 in Rooms with ASE1000/250 < 20% of Room area

	С	D	E	F	G	H	I	J	К
			Include In	sDA	300/50	ASE 1	1000/250	sD	VASE
Nome	Numero	Area	Daylighting	%	Points	%	Pass	%	Points
Meeting	-1.03	33 m²						l	
Veeting	0.01	249 m²		100	3 nt	4	Yes	100	3 pt
Reception	0.02	105 m ²		94	3 pt	1	Yes	94	3 pt
Zona Ristoro	0.03	134 m²		98	3 pt	1	Yes	98	3 pt
Veeting	0.04	72 m²		100	3 pt	16	Yes	100	3 pt
Office	0.39	12 m²		100	3 pt	90	No	0	none
Veeting	0.40	13 m²		98	3 pt	0	Yes	98	3 pt
Office	0.38	12 m²		83	3 pt	13	Yes	83	3 pt
Ufficio Open Space	0.35	142 m ²		89	3 pt	25	No	0	none
	(2) 2 2	1			1	1	1	ļ	1
Office	1.02	50 m²		83	3 pt	0	Yes	83	3 pt
Neetina	1.01	36 m²		62	2 pt	8	Yes	62	2 pt
Neeting	1.22	38 m²		38	none	1	Yes	38	none
Office	1.21	19 m²		95	3 pt	4	Yes	95	3 pt
Office	1.04	16 m²		100	3 pt	0	Yes	100	3 pt
Office	1.06	26 m²		34	none	0	Yes	34	none
Office	1.18	27 m²		3	none	2	Yes	3	none
Office	1.37	24 m²		75	3 pt	0	Yes	75	3 pt
Office	1.38	25 m²		83	3 pt	11	Yes	83	3 pt
Office	1.39	34 m²		90	3 pt	19	Yes	90	3 pt
Veeting	1.40	57 m²		75	3 pt	8	Yes	75	3 pt
F		G		Н			J		ĸ
9	DA 300/	/50		ŀ	ASE 1000/250			sDA/AS	E
		Point	s	%		Pass	%	_	Points

%	Points	%	Pass	%	Points
					1
100	2			100	2
94	3 pt	4 1	Yes	94	3 pt 3 pt
98	3 pt	1	Yes	98	3 pt





structure the BIM data to insert them automatically in the LEED Online Spreadsheet





All the previous methodology was under BIM level 2 maturity level

Currently



The future of interoperability





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





Ontologies & Semantic web





Ontologies & Semantic web







H2020 G.A. 820773

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







Source: (Zhang D., et. 2019)

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iGBR framework - Example





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).



IFC	ifcOWL
Schema	Ontology
Simple data type	owl:class + owl:DatatypeProperty restriction
Defined data type	owl:class
Aggregation data type SET data type LIST & ARRAY data type	owl:class non-functional owl:ObjectProperty indirect subclass of express:List
Constructed data type SELECT data type NUMERATION data type	owl:class rdfs:subClassOf for owl:classes rdf:type for owl:NamedIndividuals
Entity data type Attributes	owl:class object properties
Derive attr WHERE rules Functions Rules	

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Thank you





