BIM4LEED

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

Paper session: Renovation

SUSTAINABLE PLACES

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

The team

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Open Project

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Green Building Council Italia

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R2M Solution

BIM4LEED

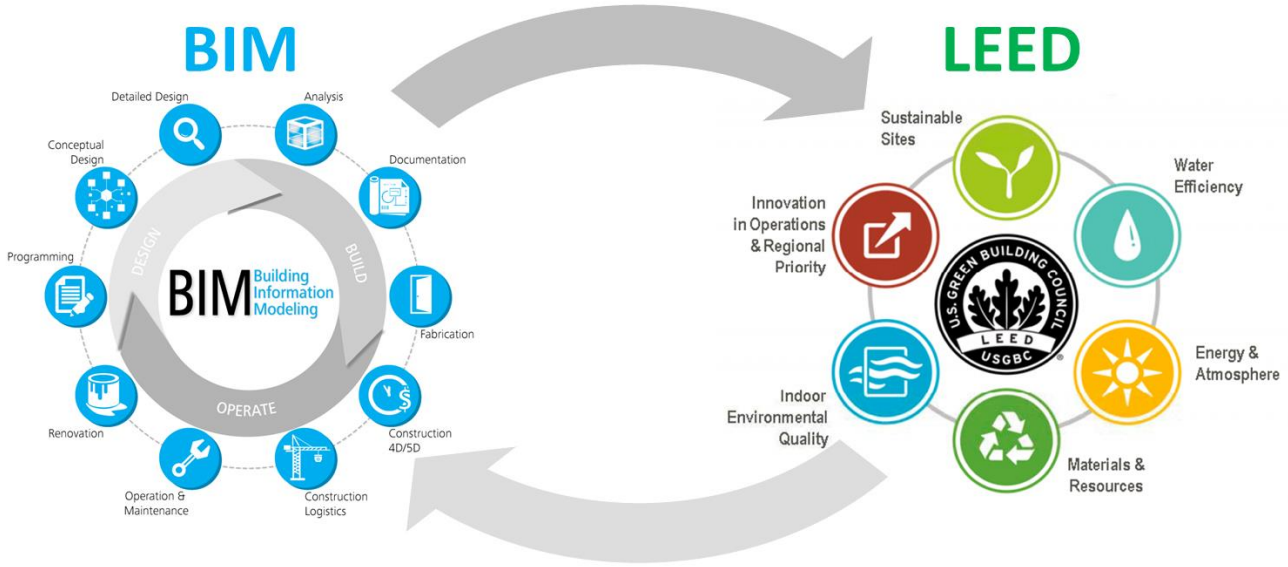
SUSTAINABLE PLACES

H2020 G.A. 820773

Presentation structure

BIM4LEED

- 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



SUSTAINABLE PLACES

What is Green BIM?

BIM4LEED

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)

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What is BIM 7D?

BIM4LEED

"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)

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What is LEED?

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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.

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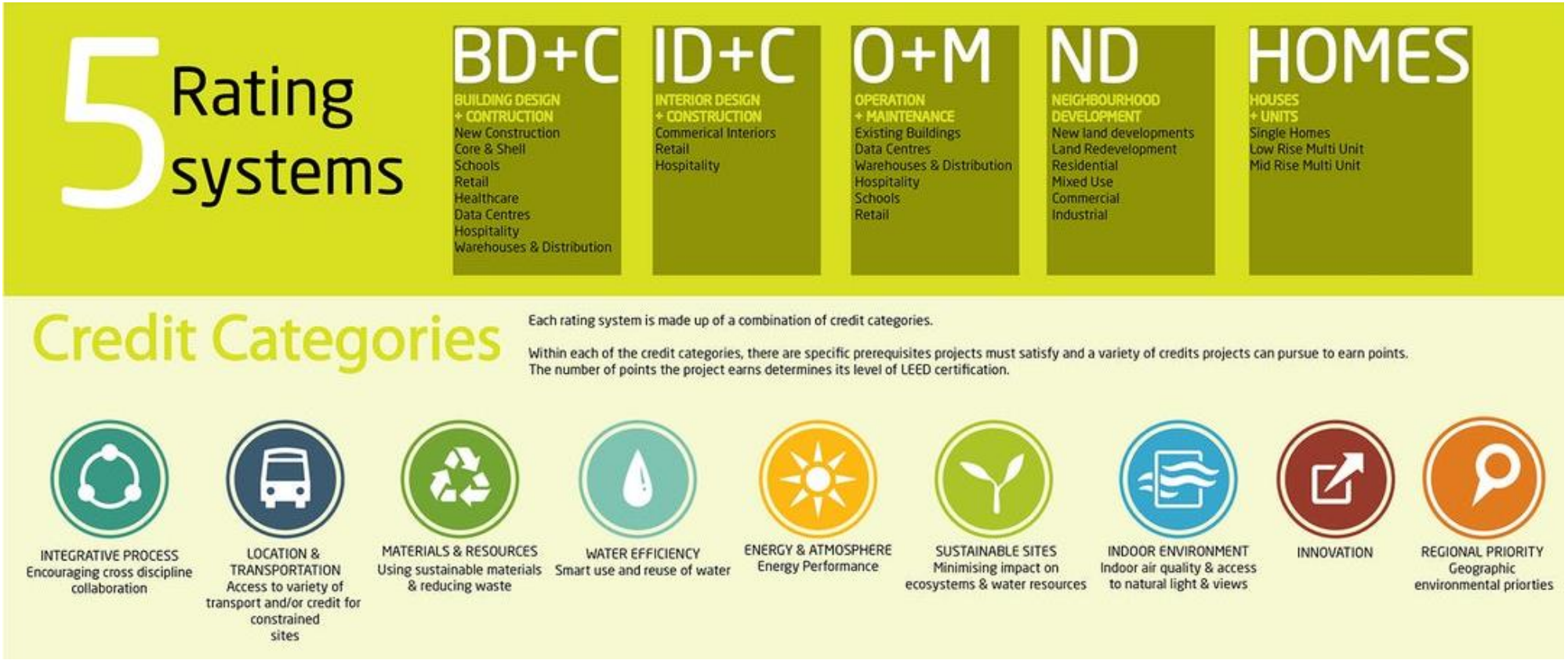
What is LEED?

BIM4LEED



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LEED Credits

LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Project Name:
Date:

Y	?	N			
			Credit	Integrative Process	1

18	0	0	**Location and Transportation**		16
16			Credit	LEED for Neighborhood Development Location	16
1			Credit	Sensitive Land Protection	1
1			Credit	High Priority Site	2
			Credit	Surrounding Density and Diverse Uses	5
			Credit	Access to Quality Transit	5
			Credit	Bicycle Facilities	1
			Credit	Reduced Parking Footprint	1
			Credit	Green Vehicles	1

0	0	0	**Sustainable Sites**		10
Y			Prereq	Construction Activity Pollution Prevention	Required
			Credit	Site Assessment	1
			Credit	Site Development - Protect or Restore Habitat	2
			Credit	Open Space	1
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1

0	0	0	**Water Efficiency**		11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	2
			Credit	Indoor Water Use Reduction	6
			Credit	Cooling Tower Water Use	2
			Credit	Water Metering	1

0	0	0	**Energy and Atmosphere**		33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Enhanced Commissioning	6
			Credit	Optimize Energy Performance	18
			Credit	Advanced Energy Metering	1
			Credit	Demand Response	2
			Credit	Renewable Energy Production	3
			Credit	Enhanced Refrigerant Management	1
			Credit	Green Power and Carbon Offsets	2

0	0	0	**Materials and Resources**		13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	Construction and Demolition Waste Management	2

0	0	0	**Indoor Environmental Quality**		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight	3
			Credit	Quality Views	1
			Credit	Acoustic Performance	1

0	0	0	**Innovation**		6
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1

0	0	0	**Regional Priority**		4
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1

18	0	0	**TOTALS**	Possible Points: 110

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

16
10
11
33
13
16
6
4
1

110

SUSTAINABLE PLACES

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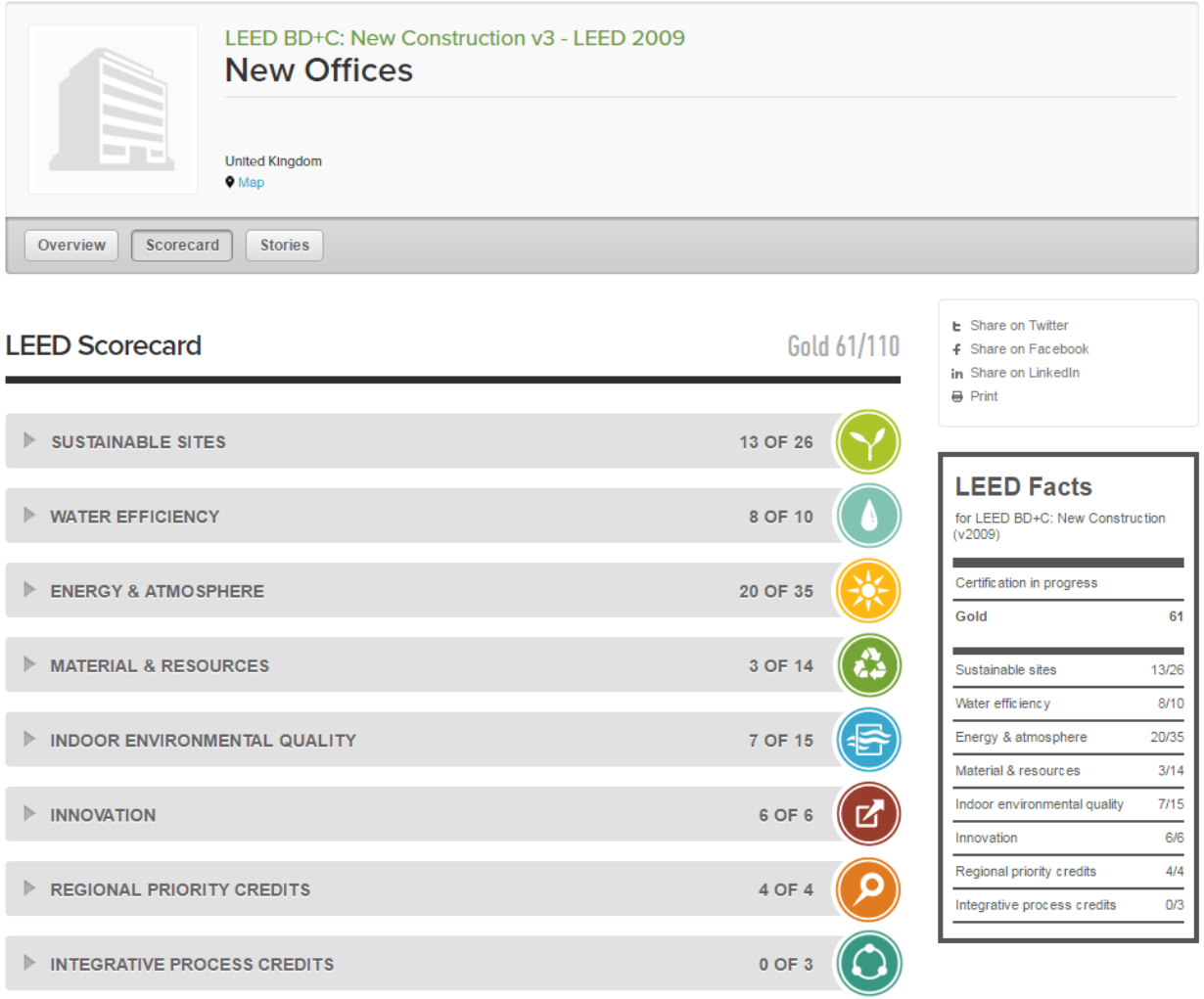
LEED Certification



LEED BD+C: New Construction v3 - LEED 2009

New Offices

United Kingdom
Map

Overview | Scorecard | Stories

LEED Scorecard

Gold 61/110

SUSTAINABLE SITES	13 OF 26
WATER EFFICIENCY	8 OF 10
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

Share on Twitter
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Print

LEED Facts

for LEED BD+C: New Construction (v2009)

Certification in progress	
Gold	61
Sustainable sites	13/26
Water efficiency	8/10
Energy & atmosphere	20/35
Material & resources	3/14
Indoor environmental quality	7/15
Innovation	6/6
Regional priority credits	4/4
Integrative process credits	0/3

SUSTAINABLE PLACES

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LEED Rating Levels

BIM4LEED

Certified

40-49 points earned

Silver

50-59 points earned

Gold

60-79 points earned

Platinum

80+ points earned

SUSTAINABLE PLACES

BIM & LEED intersection

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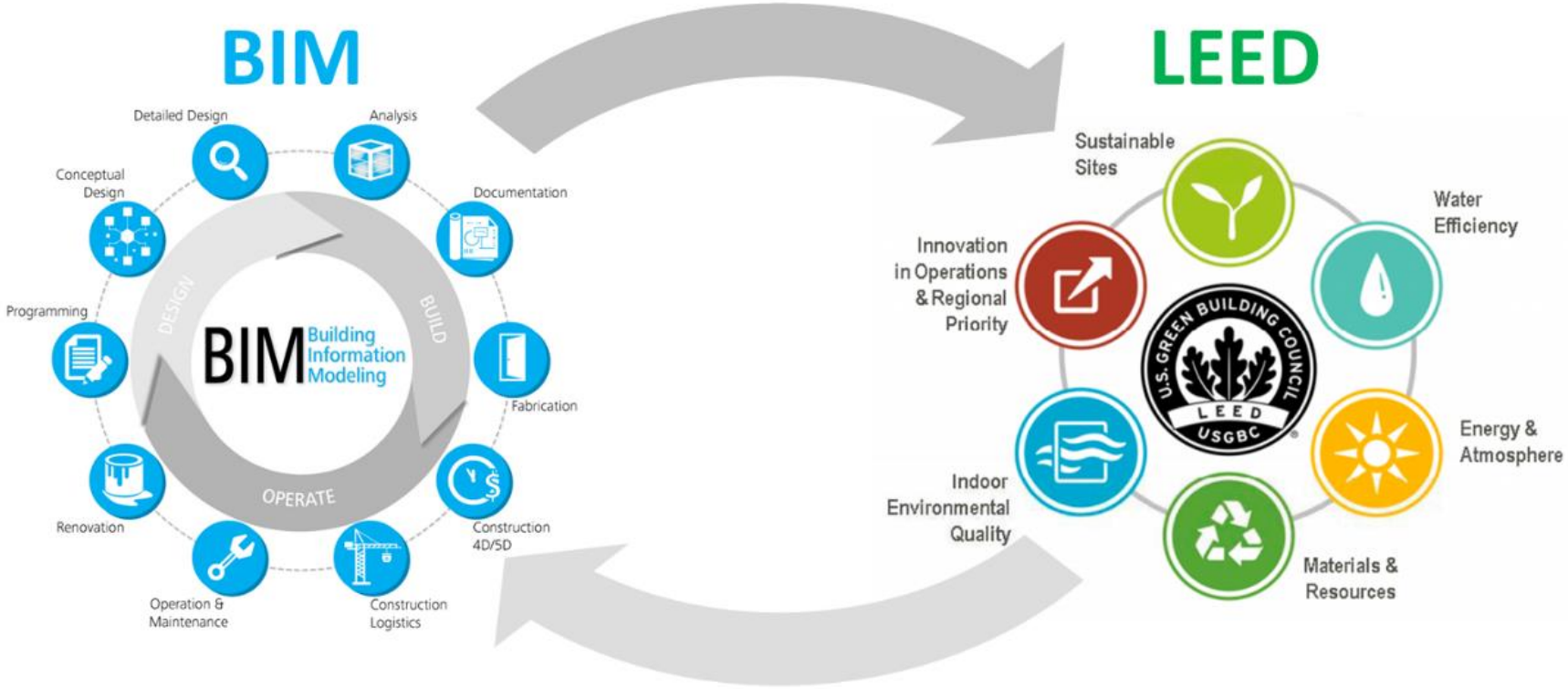
Efficiency
Quality
Sustainability

SUSTAINABLE PLACES

BIM & LEED intersection



RESEARCH

AEC INDUSTRY

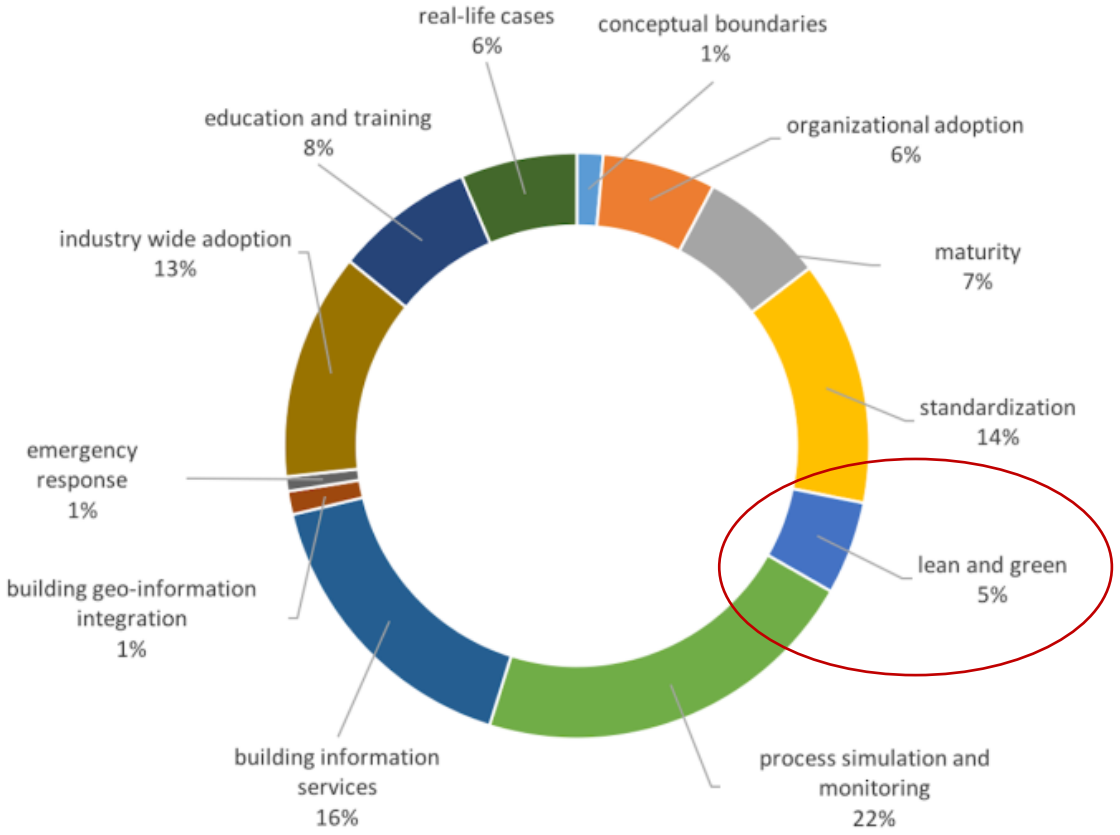
SOFTWARE INDUSTRY

BIM4LEED

SUSTAINABLE PLACES

BIM & LEED intersection: RESEARCH

RESEARCH PAPERS



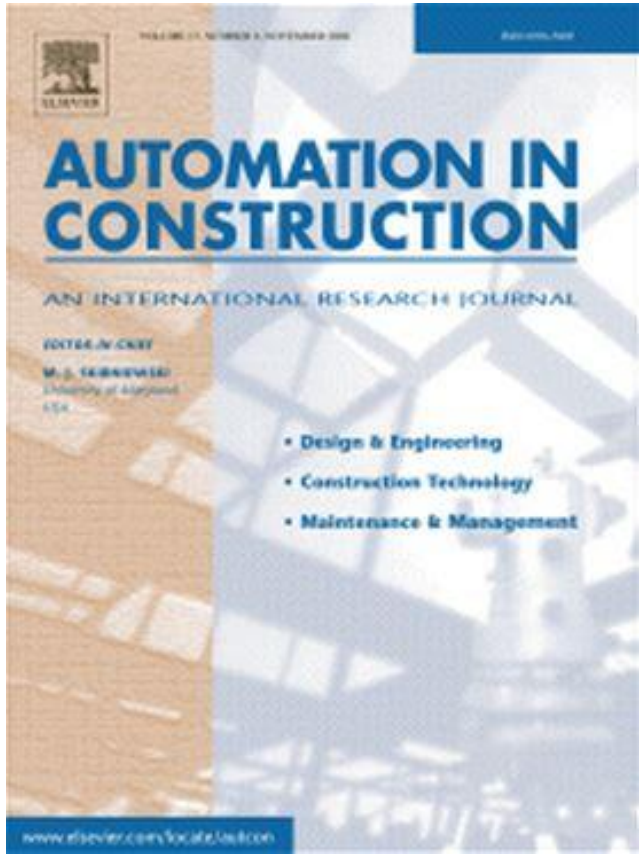
A study covering 1500 papers published over the past 25 years by BIM researchers from 65 countries

Cb Amarnath (2016).
"Global trends in BIM research"
BIMe Initiative

BIM4LEED

SUSTAINABLE PLACES

BIM & LEED intersection: RESEARCH



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

SUSTAINABLE PLACES

BIM & LEED intersection: AEC INDUSTRY

↓

PROJECTS

BIM4LEED

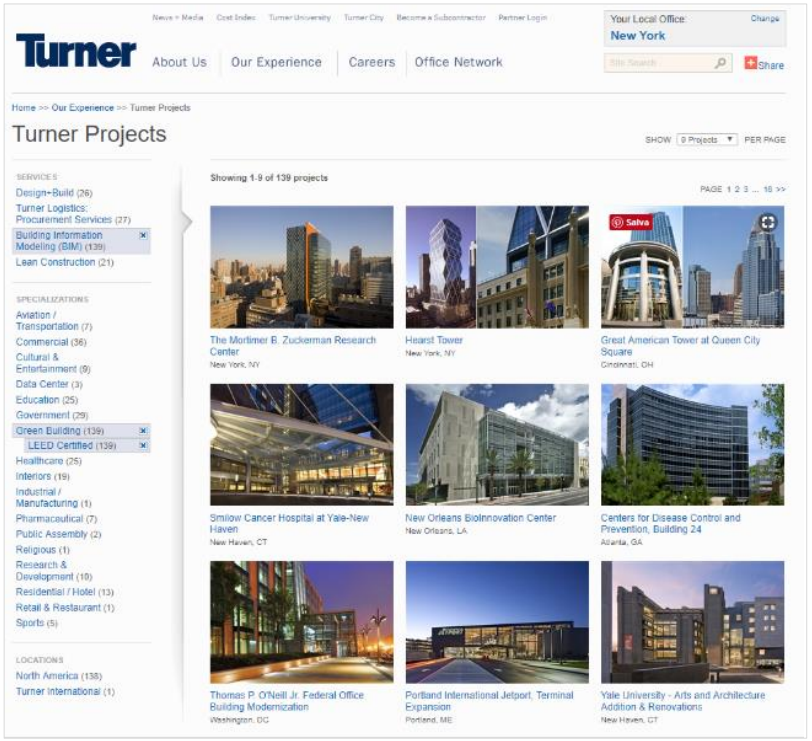
SUSTAINABLE PLACES

BIM & LEED intersection: AEC INDUSTRY

BIM4LEED

USA

Turner Construction: 139
LEED-BIM projects



EUROPE

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

SUSTAINABLE PLACES

BIM & LEED intersection: SOFTWARE INDUSTRY

BIM4LEED

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
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):

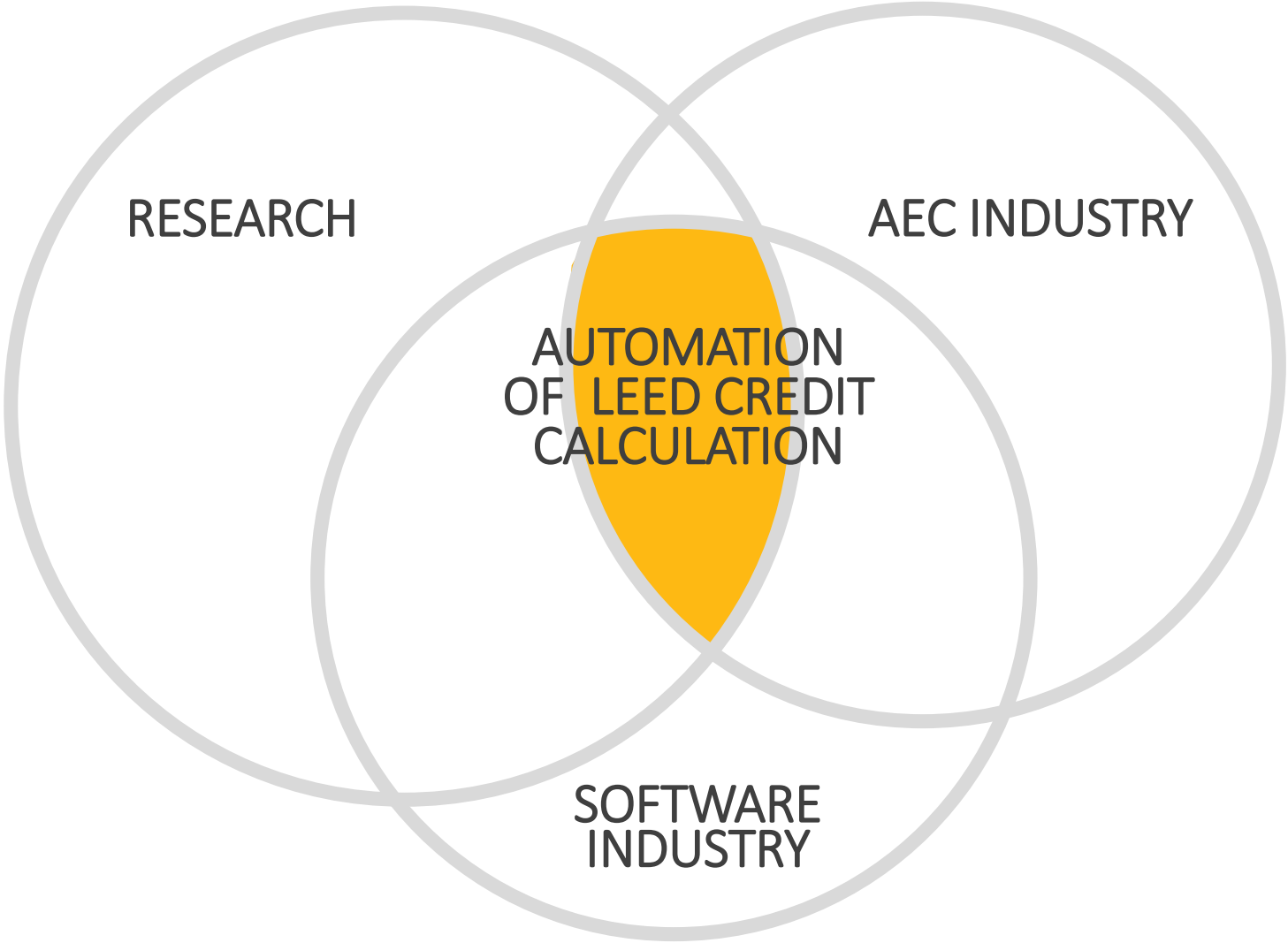
- Minimum Energy Performance prerequisite 2 (required)
- Optimize Energy Performance credit 1

Under Indoor Environmental Quality (EQ):

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

SUSTAINABLE PLACES

BIM & LEED intersection



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SUSTAINABLE PLACES


NOT YET
COMPLETELY
AUTOMATED

The only way is interoperability

SUSTAINABLE PLACES

BIM4LEED

Interoperability Issues

BIM4LEED

"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

SUSTAINABLE PLACES

Interoperability Issues

TRANSLATOR

SAME SOFTWARE HOUSE

DIFFERENT SOFTWARE HOUSE

SUSTAINABLE PLACES

BIM4LEED

Interoperability Issues

CLOSED BIM

REVIT

BI-DIRECTIONAL

INSIGHT 360

ARCHICAD

BI-DIRECTIONAL

ECODESIGNER

OPENBUILDINGS

BI-DIRECTIONAL

AECOSIM ENERGY SIMULATOR
&
HEVACOMP

SUSTAINABLE PLACES

Interoperability Issues

OPEN BIM™

BIM4LEED

SUSTAINABLE PLACES

BIM

ANALYSIS TOOL

HARDLY

BI-DIRECTIONAL

gbXML

DXF

DesignBuilder SOFTWARE

EnergyPlus

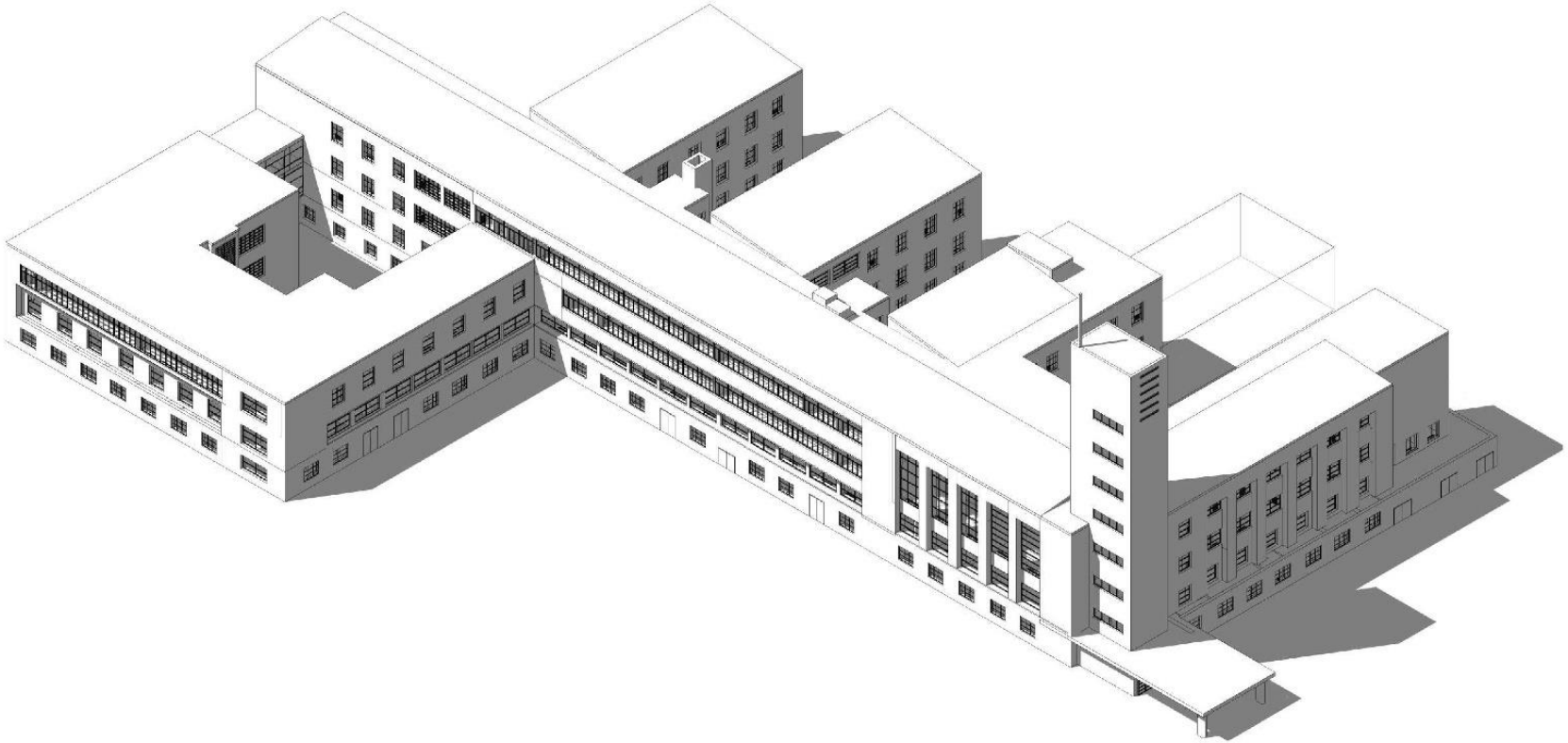
IES

eQUEST

EDSL Tas

Interoperability Issues

BIM



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

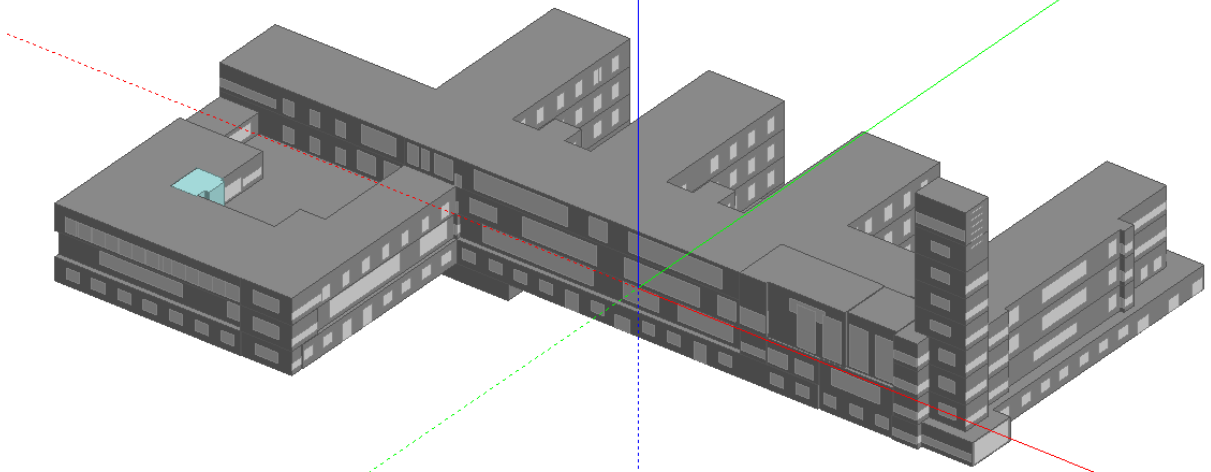
Interoperability Issues

BIM

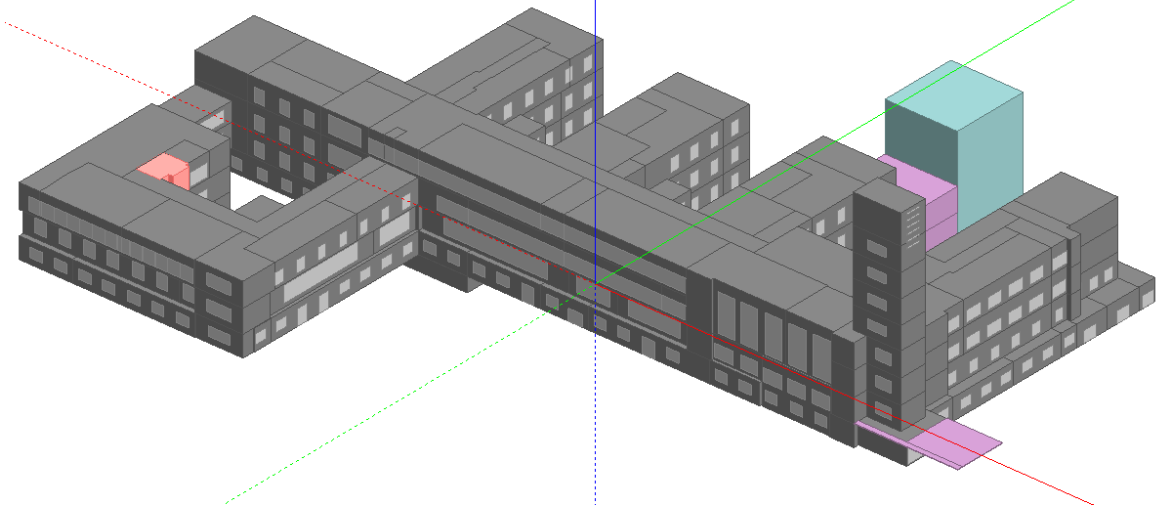
ENERGY ANALYSIS TOOL

gbXML

DesignBuilder SOFTWARE



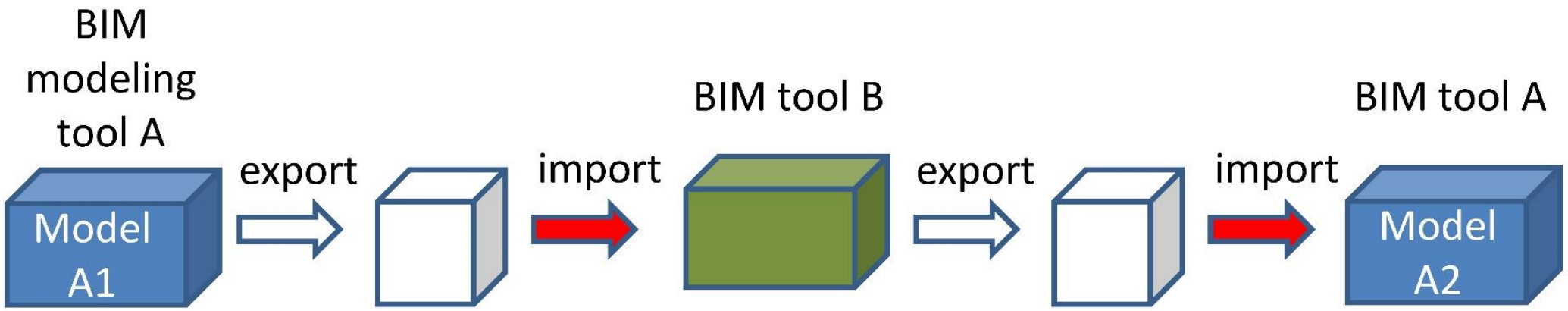
AFTER RE-CREATING GEOMETRY



SUSTAINABLE PLACES

4LEED

Interoperability Issues: a BIM 'round trip'



such that A1 = A2, for any model A1

(the 'Sacks Test')

Interoperability Issues

OPEN BIM™ + VISUAL SCRIPTING

BIM





MAYBE

BI-DIRECTIONAL








ANALYSIS TOOL








SUSTAINABLE PLACES

BIM4LEED

The only way for total automation

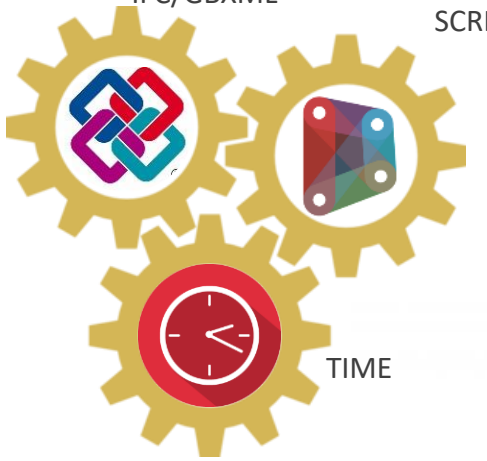
BIM4LEED

OPEN BIM™

BIM

DEEP
UNDERSTANDING
IFC/GBXML

LEARNING VISUAL
SCRIPTING



TIME

LEED

SUSTAINABLE PLACES

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

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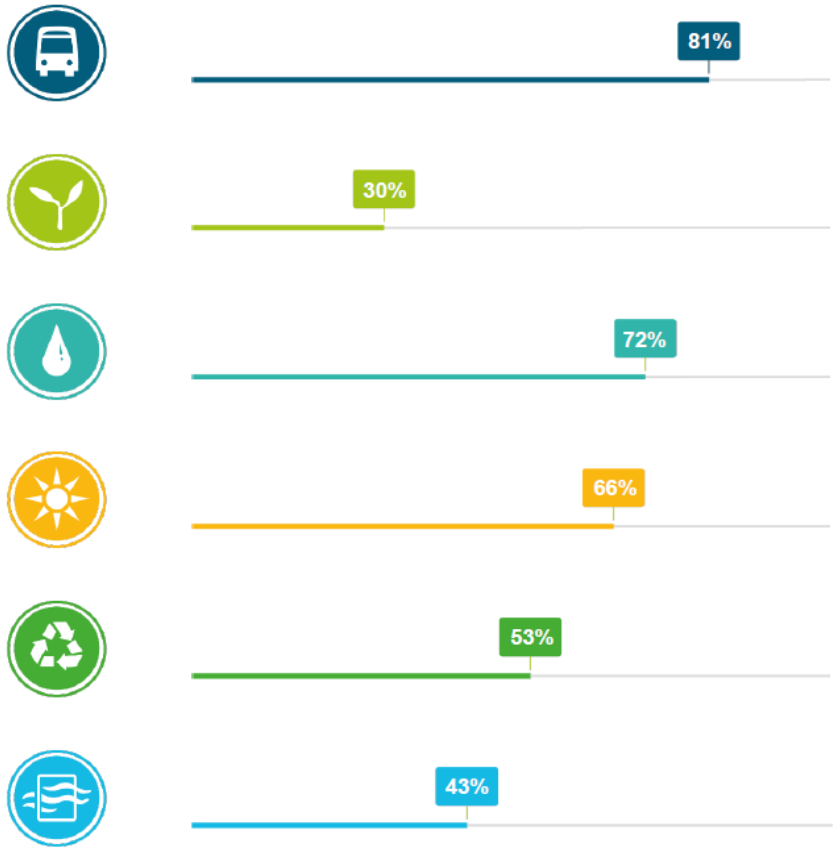
LEED®-NC credits that can be earned using BIM-based performance analysis software			Can the LEED® credit be earned using BIM? (yes/no)	Performance analysis software that could be or was used? VE/REVIT	Is the credit being attempted by Salisbury Building?	Was the credit validated in the case study? (yes/no)
LEED credit	Credit description	LEED® points				
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	1	No		Yes	
SSc4.2	Bicycle 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	
Water efficiency						
WEc1.1 and WEc1.2	Water efficient landscaping	2	Yes	Revit	No	
WEc2	Innovative wastewater technologies	1	Yes	VE	No	Yes
WEc3.1 and WEc3.2	Water use reduction	2	Yes	VE	Yes	Yes
Energy and atmosphere						
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	
EAc5	Measurement and verification	1	No		No	
EAc6	Green power	1	No		No	
Materials and resources						
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		No	
MRc7	Certified wood	1	Yes	Revit	Yes	
Indoor environmental quality						
EQp1	Minimum indoor air quality (IAQ) performance	required	No		Yes	
EQp2	Environmental tobacco smoke (ETS) control	required	No		Yes	
EQc1	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	
EQc6.2	Controllability of systems — thermal comfort	1	No		Yes	
EQc7.1	Thermal comfort — design	1	Yes	VE	Yes	Yes
EQc7.2	Thermal comfort — verification	1	No		Yes	
EQc8.1	Daylight and views — daylight	1	Yes	VE	No	Yes
EQc8.2	Daylight and views — views	1	Yes	VE	No	
Innovation and design process						
IDc1	Innovation in design	4	Yes	Revit, VE	Yes	
IDc2	LEED accredited professional	1	No		Yes	

SUSTAINABLE PLACES

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

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

BIM4LEED



L22

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

SUSTAINABLE PLACES

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

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SUSTAINABLE PLACES

81%

	Location and Transportation	
Credit	LEED for Neighborhood Development Location	16
Credit	Sensitive Land Protection	1
Credit	High Priority Site	2
Credit	Surrounding Density and Diverse Uses	5
Credit	Access to Quality Transit	5
Credit	Bicycle Facilities	1
Credit	Reduced Parking Footprint	1
Credit	Green Vehicles	1 + 1

30%

	Sustainable Sites	
Prereq	Construction Activity Pollution Prevention	Required
Credit	Site Assessment	1
Credit	Site Development - Protect or Restore Habitat	2
Credit	Open Space	1
Credit	Rainwater Management	3
Credit	Heat Island Reduction	2
Credit	Light Pollution Reduction	1

72%

	Water Efficiency	
Prereq	Outdoor Water Use Reduction	Required
Prereq	Indoor Water Use Reduction	Required
Prereq	Building-Level Water Metering	Required
Credit	Outdoor Water Use Reduction	2
Credit	Indoor Water Use Reduction	6
Credit	Cooling Tower Water Use	2
Credit	Water Metering	1

66%

	Energy and Atmosphere	
Prereq	Fundamental Commissioning and Verification	Required
Prereq	Minimum Energy Performance	Required
Prereq	Building-Level Energy Metering	Required
Prereq	Fundamental Refrigerant Management	Required
Credit	Enhanced Commissioning	6
Credit	Optimize Energy Performance	18
Credit	Advanced Energy Metering	1
Credit	Demand Response	2
Credit	Renewable Energy Production	3
Credit	Enhanced Refrigerant Management	1
Credit	Green Power and Carbon Offsets	2

53%

	Materials and Resources	
Prereq	Storage and Collection of Recyclables	Required
Prereq	C&D Waste Management Planning	Required
Credit	Building Life-Cycle Impact Reduction	5
Credit	Building Product Optimization EPD	2
Credit	Sourcing of Raw Materials	2
Credit	Material Ingredients	2
Credit	Construction and Demolition Waste Management	2

37%

	Indoor Environmental Quality	
Prereq	Minimum Indoor Air Quality Performance	Required
Prereq	Environmental Tobacco Smoke Control	Required
Credit	Enhanced Indoor Air Quality Strategies	2
Credit	Low-Emitting Materials	3
Credit	Construction Indoor Air Quality Management Plan	1
Credit	Indoor Air Quality Assessment	2
Credit	Thermal Comfort	1
Credit	Interior Lighting	2
Credit	Daylight	3 + 1
Credit	Quality Views	1
Credit	Acoustic Performance	1

L22

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

BIM4LEED

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 Environmental Quality		**16**				
41	Prereq	Minimum Indoor Air Quality Performance	Required	Option 1. ASHRAE Standard 62.1–2010			
				Option 2. CEN Standards EN 15251–2007 and EN 13779–2007	3		Revit - Dynamo
42	Prereq	Environmental Tobacco Smoke Control	Required	Option 1. No smoking (Residentioal Only)	-	2	
				Option 2. Compartmentalization of smoking areas	2		Revit
43	Credit	Enhanced Indoor Air Quality Strategies	2	Option 1. Enhanced IAQ strategies	2		Revit
				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				
49	Credit	Daylight	3	Option 1. Simulation—Spatial Daylight Autonomy	5	-	Revit - Plug-in: Daylight Insight 360
				Option 2. Simulation—Illuminance Calculations	-		
				Option 3. Measurement	-		
50	Credit	Quality Views	1		2	-	Revit
51	Credit	Acoustic Performance	1				

SUSTAINABLE PLACES

BIM4LEED Rating

BIM4LEED

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

0 1 2 3 4 5

SUSTAINABLE PLACES

BIM4LEED Rating: 0

BIM4LEED

0 .

You can’t verify it in the BIM Authoring Tool

SUSTAINABLE PLACES

BIM4LEED Rating: 1

BIM4LEED

1 ....

You must export the model in IFC or gbXML to verify it

SUSTAINABLE PLACES

Energy and Atmosphere
Optimize Energy Performance

BIM4LEED

SUSTAINABLE PLACES

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

$$\frac{\text{(Baseline building performance – Design building performance)}}{\text{Baseline building performance}} > 6\%$$

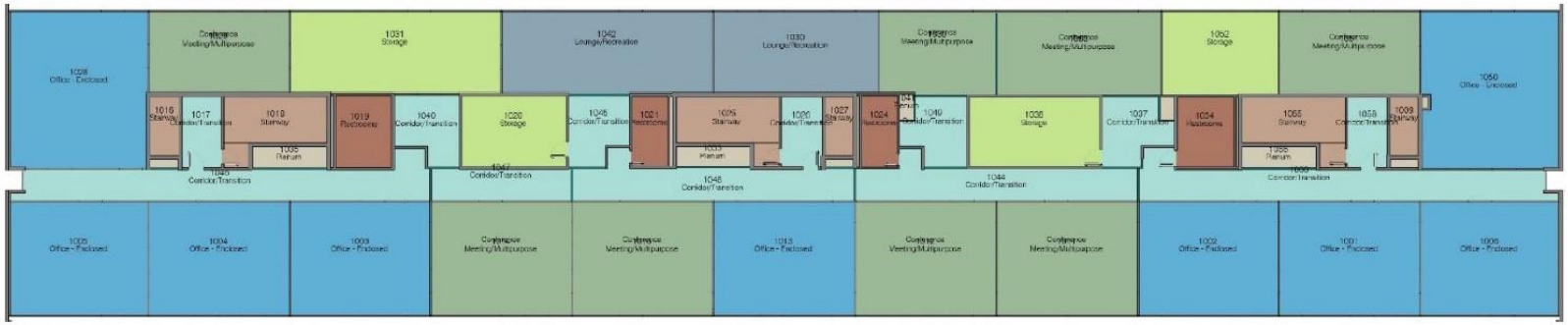
Energy Model

BIM4LEED

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

Spaces Name

- Breakroom
- Copy Room
- Electrical Shaft
- Office
- Stair/ Elevator
- Technical Room
- Conference Room
- Corridor
- Mechanical Shaft
- Shaft
- Storage
- Toilet



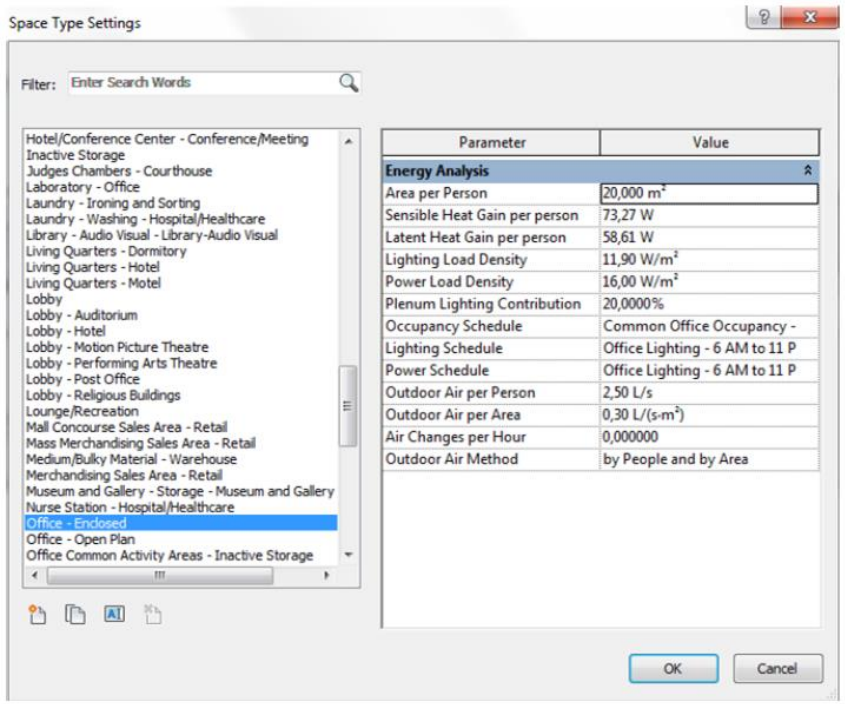
Spaces Thermal Template

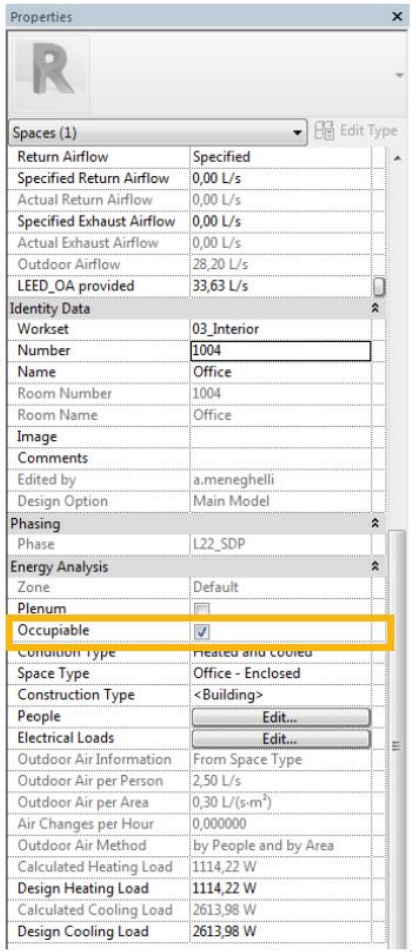
- Conference Meeting
- Lounge/ Recreation
- Plenum
- Starway
- Corridor&Trasportation
- Office - Enclosed
- Restrooms
- Storage

SUSTAINABLE PLACES

Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

Optimize Energy Performance





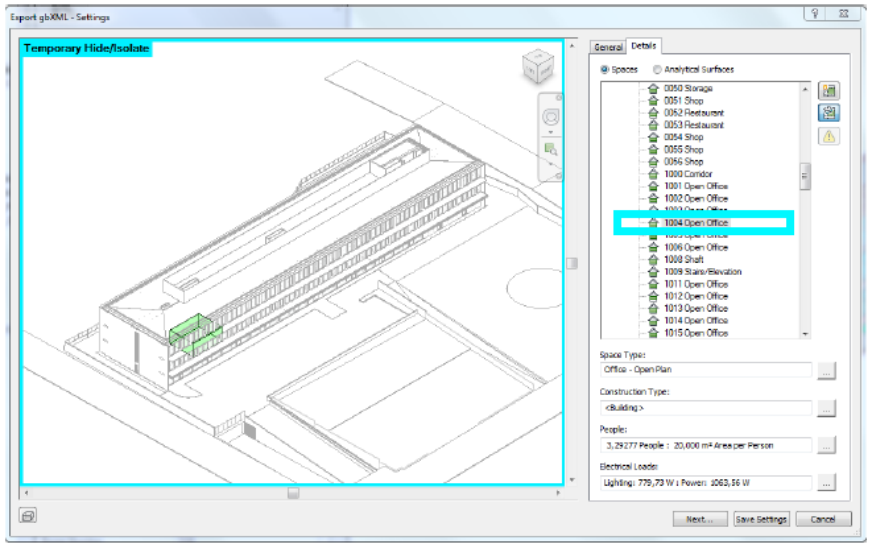
SUSTAINABLE PLACES

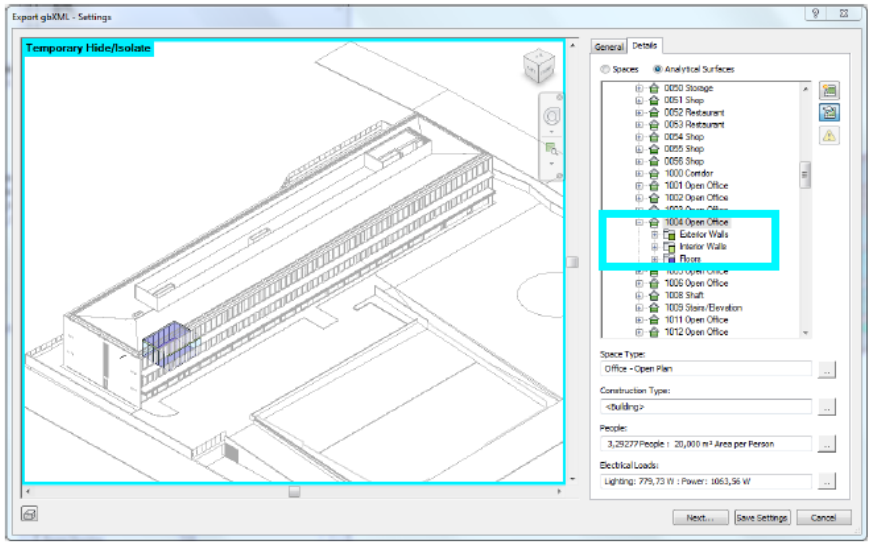
Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

BIM4LEED

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





SUSTAINABLE PLACES

Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

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
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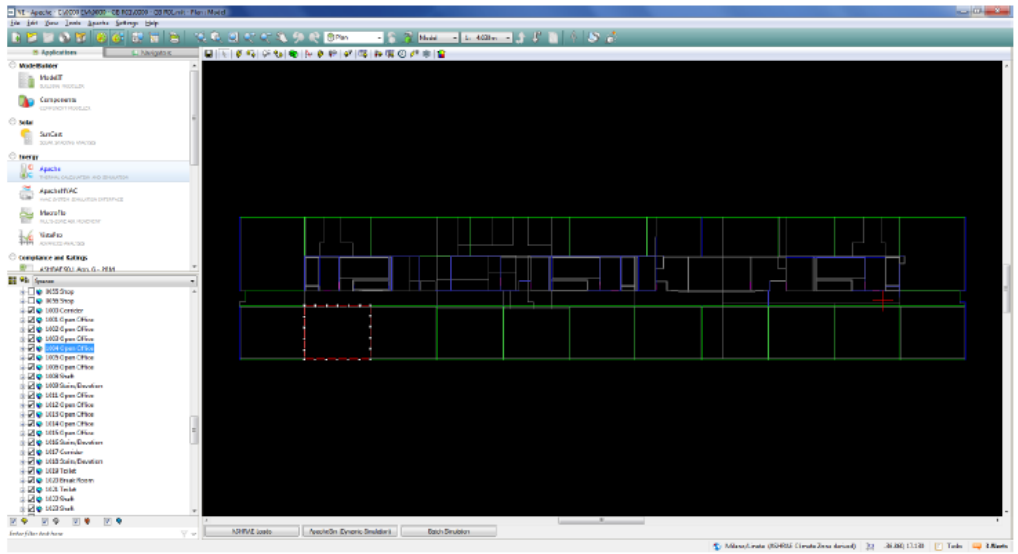
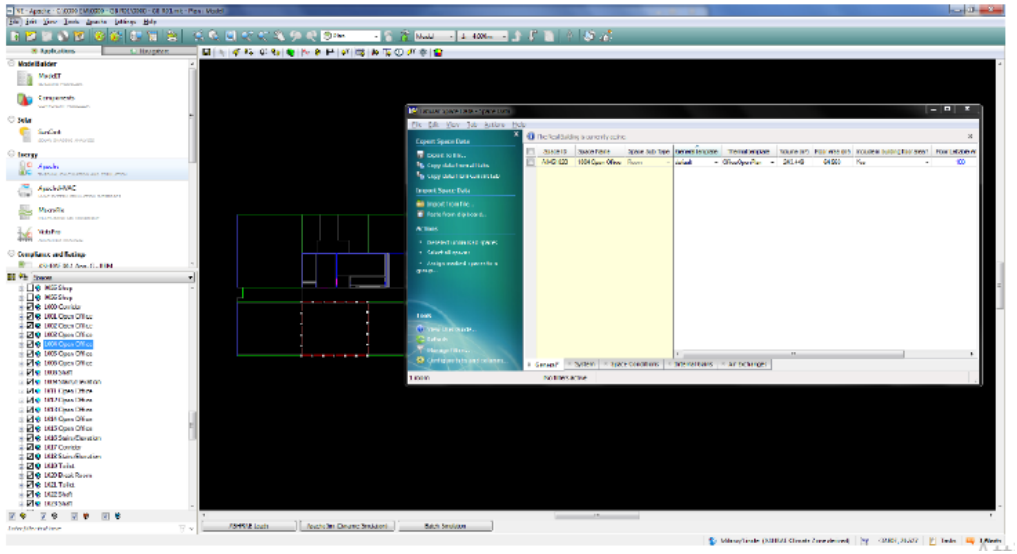
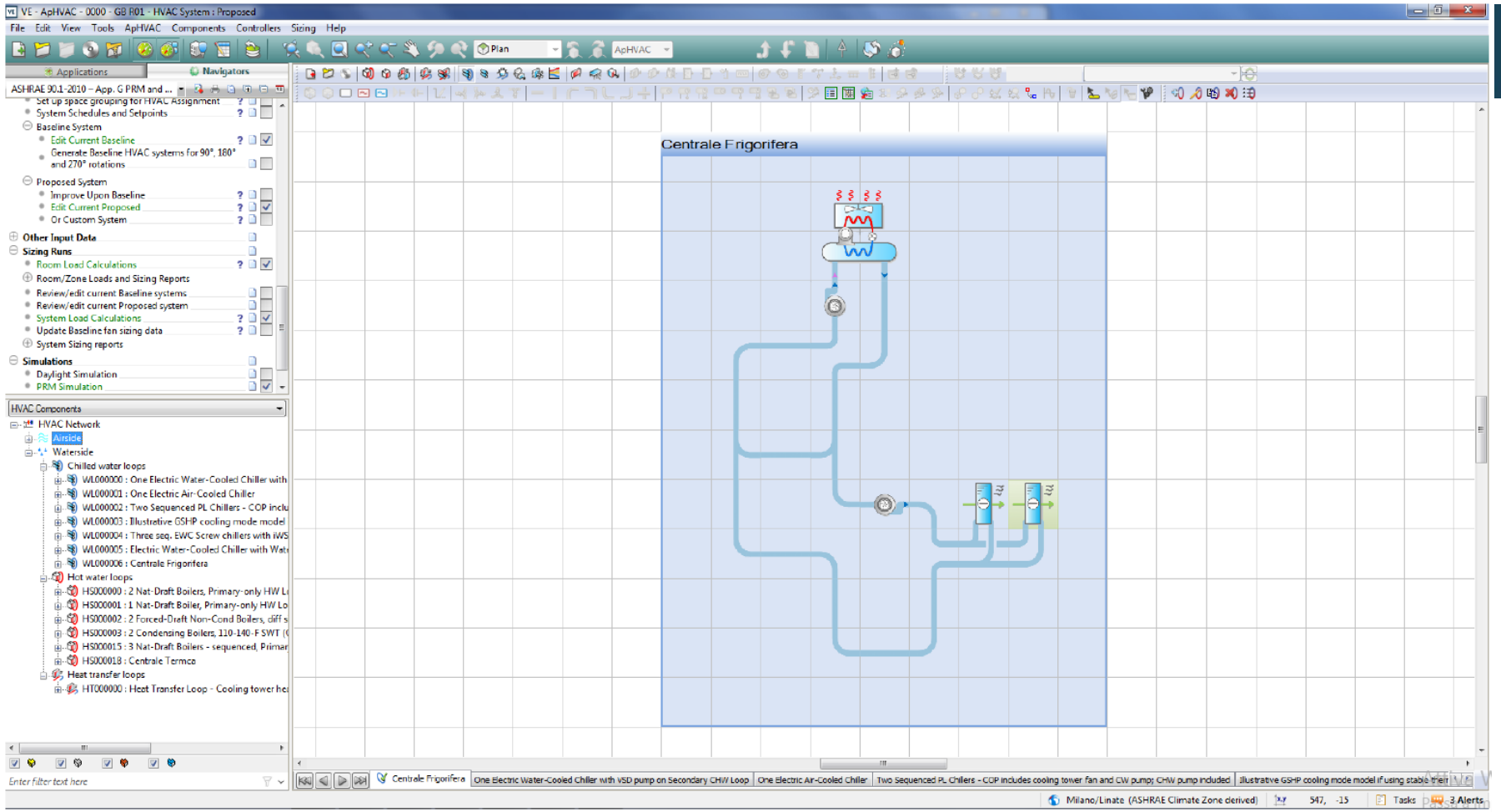




SUSTAINABLE PLACES

Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

Model potential HVAC proposed system type



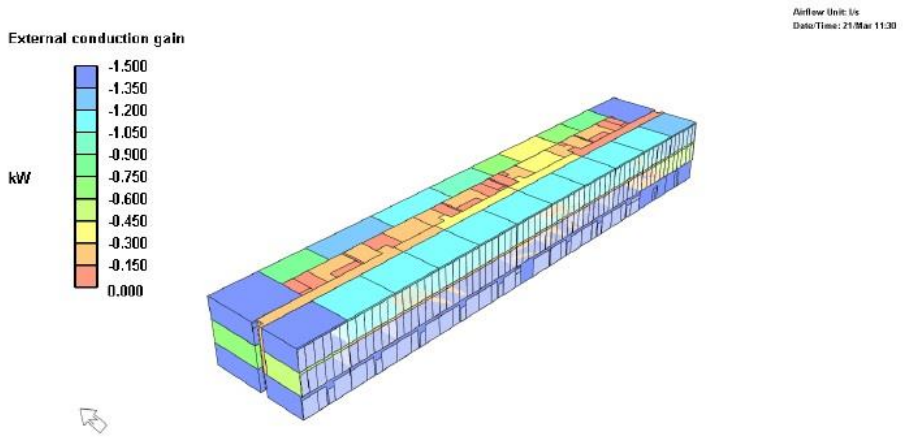
SUSTAINABLE PLACES

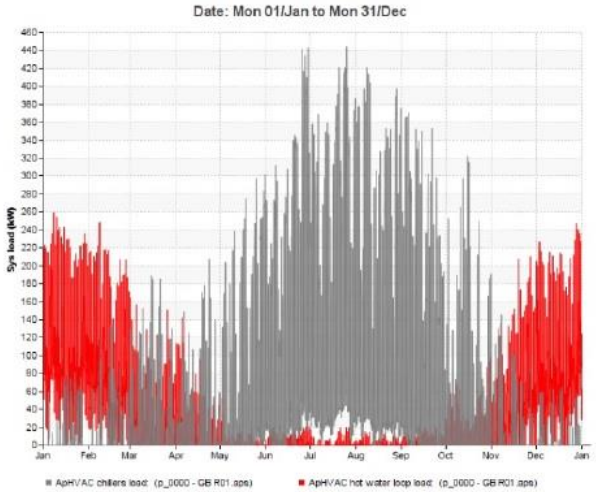
BIM4LEED

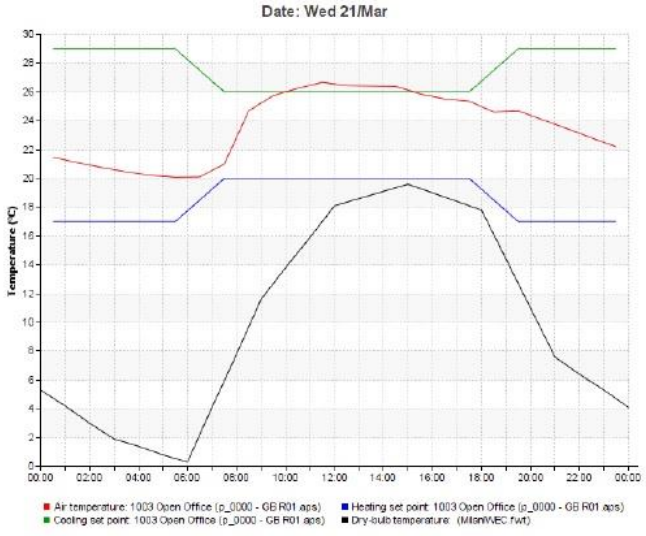
IES

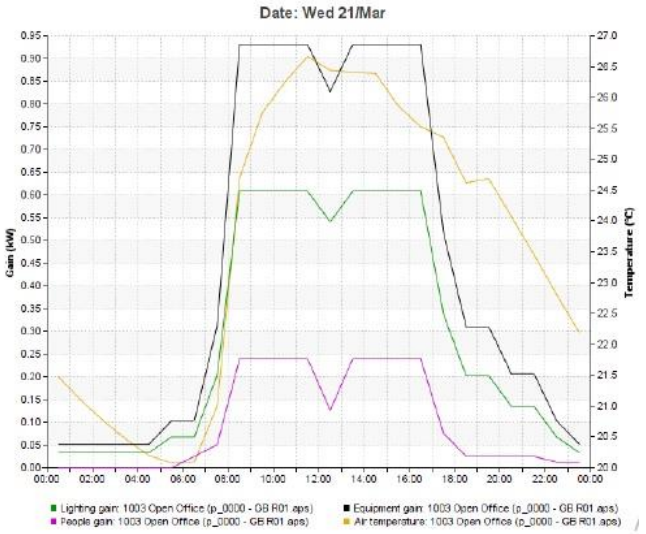
Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

Energy Simulation with IES VE







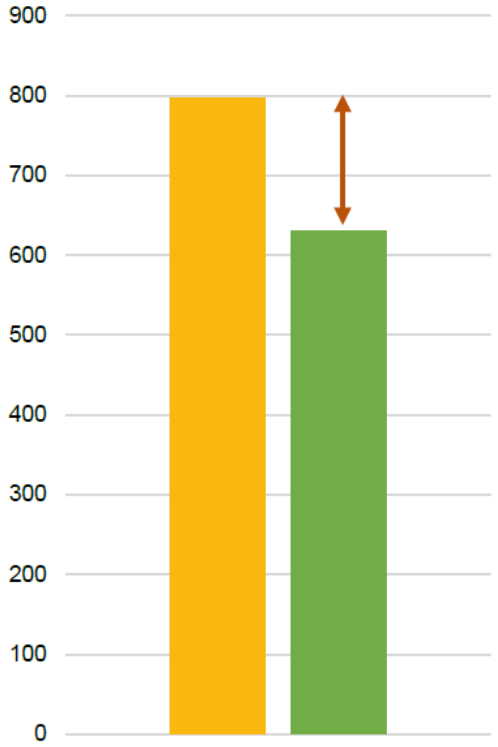


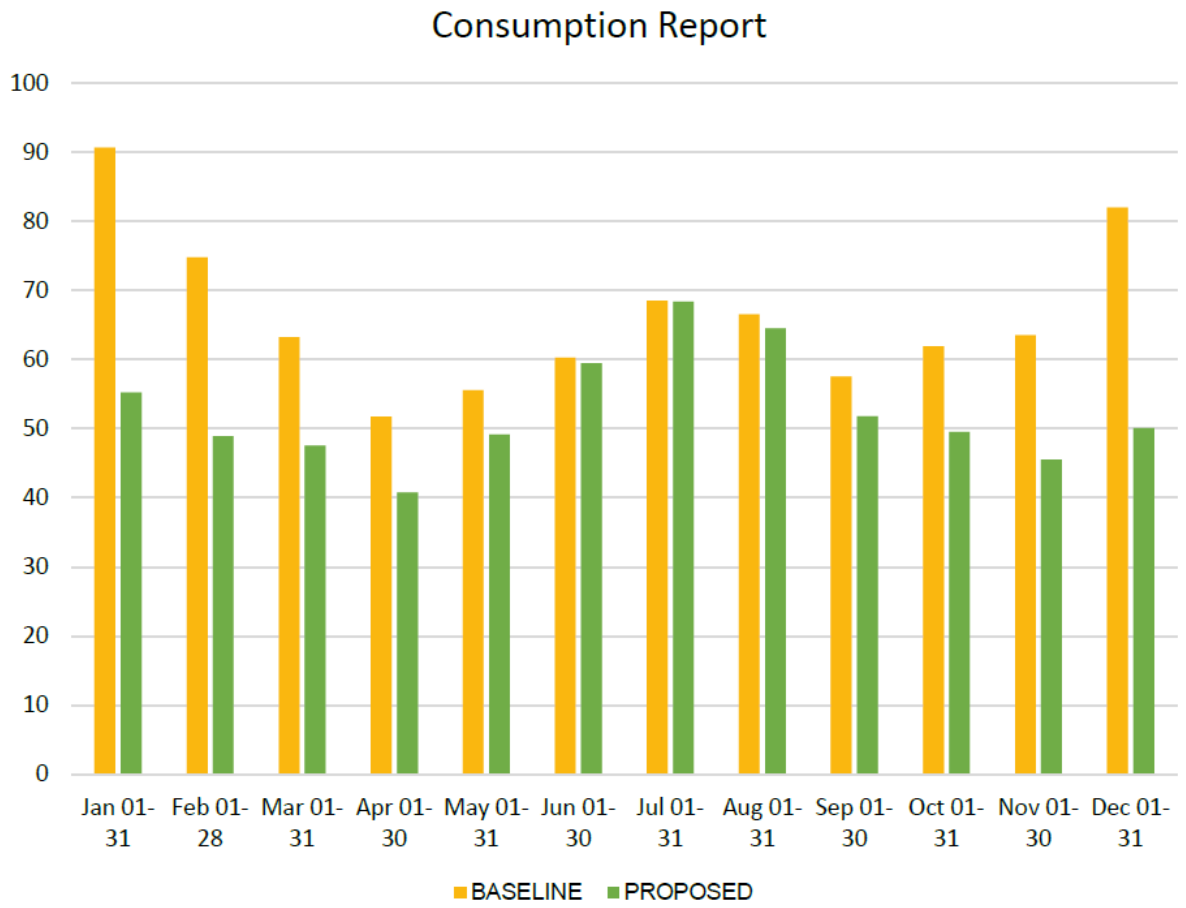
SUSTAINABLE PLACES

BIM4LEED

Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

Results and interpretation of Energy Simulation with IES VE





SUSTAINABLE PLACES

Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

Documentation from Energy Simulation

BIM4LEED

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%	11
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

$$\frac{\text{(Baseline building performance – Design building performance)}}{\text{Baseline building performance}}$$

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

SUSTAINABLE PLACES

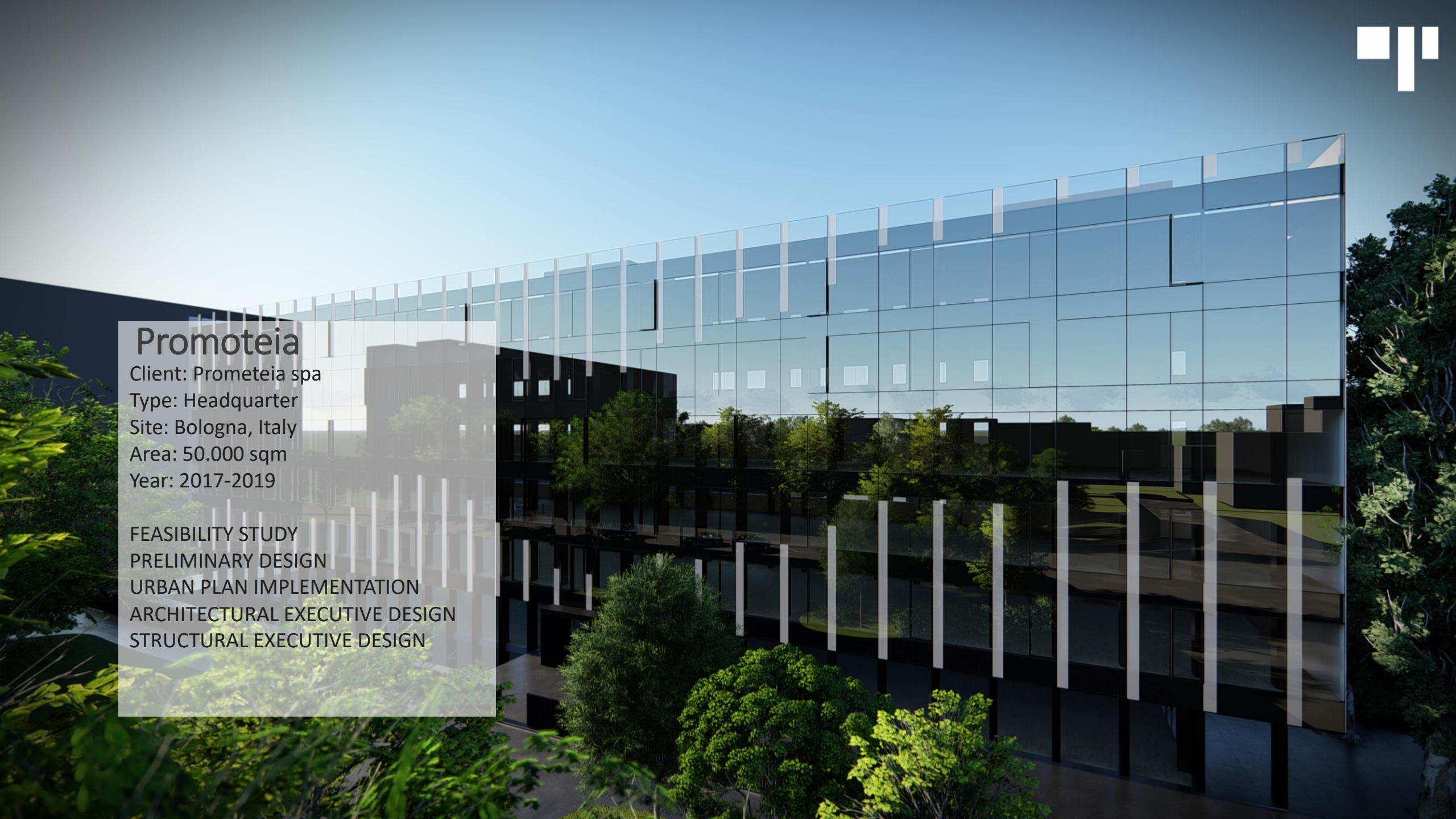
Lombardini22 DESIGN THINKING | L22 Engineering & Sustainability

BIM4LEED Rating: 2

BIM4LEED

2 —— You can use the BIM Authoring Tool “like CAD” to verify it

SUSTAINABLE PLACES



Promoteia

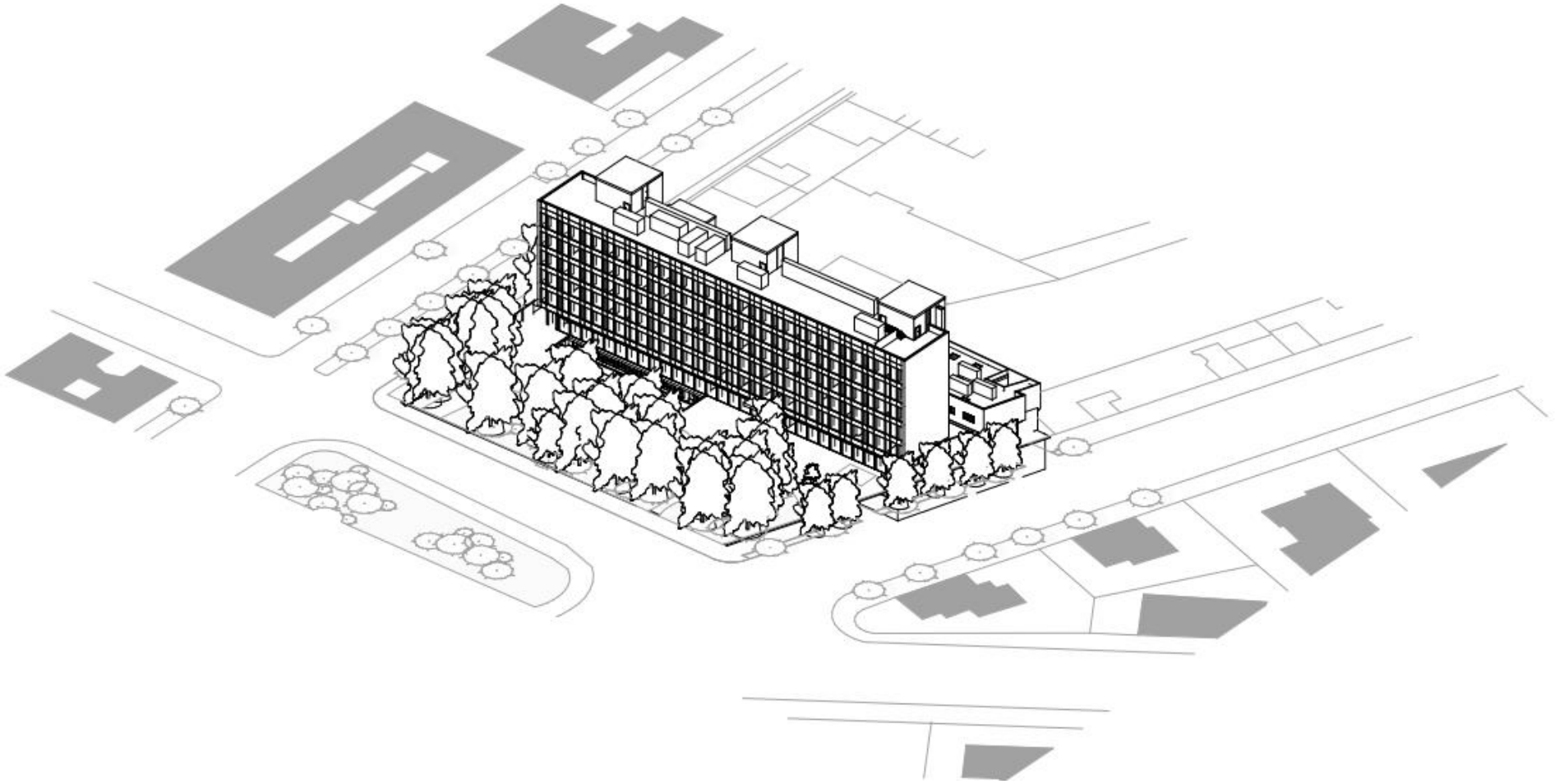
Client: Prometeia spa
Type: Headquarter
Site: Bologna, Italy
Area: 50.000 sqm
Year: 2017-2019

FEASIBILITY STUDY
PRELIMINARY DESIGN
URBAN PLAN IMPLEMENTATION
ARCHITECTURAL EXECUTIVE DESIGN
STRUCTURAL EXECUTIVE DESIGN

Case Study Project
Prometeia HQ, Bologna, Italy

BIM4LEED

SUSTAINABLE PLACES



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.

SUSTAINABLE PLACES

BIM4LEED

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

LEGEND

Project Boundary

7.5 m from building opening: Entries
Outdoor air intakes
Operable windows

3.0 m from Regularly used exterior entrance

Designated Smoking Area

Signage for no-smoking area

Signage for Designated Smoking Area

Signage for No smoking area outside the property line

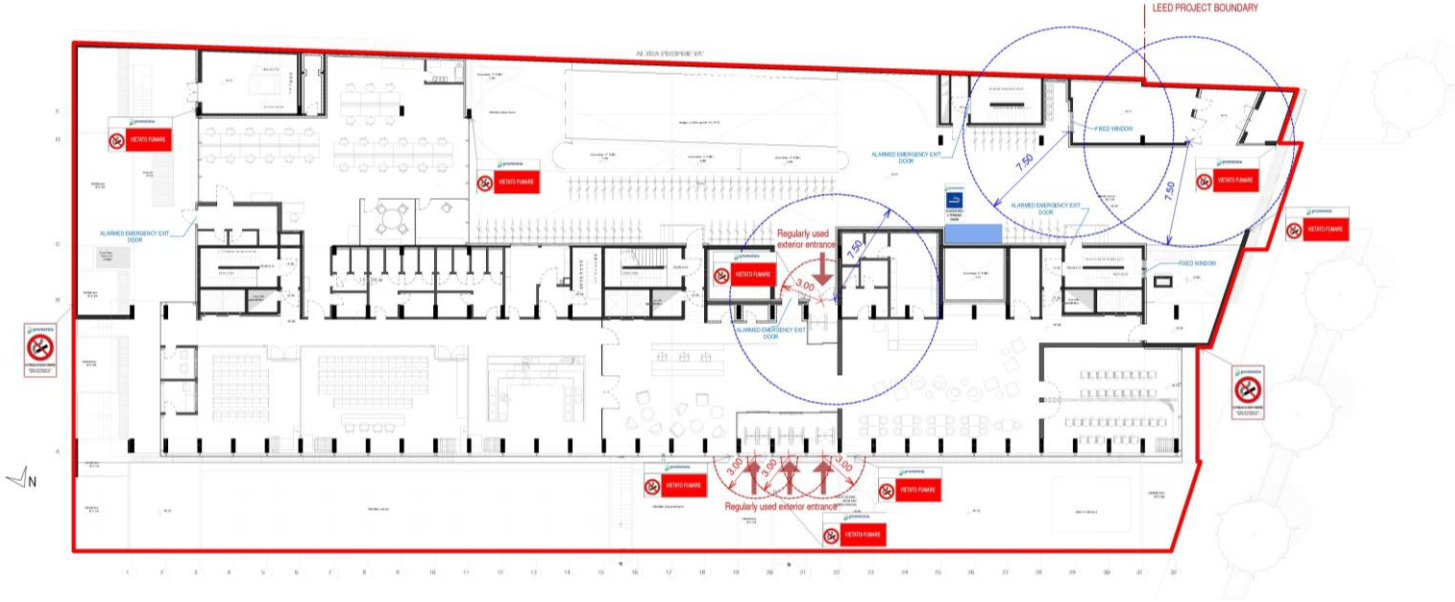
Note: Any operable window will be kept closed and alarmed as per OPR.

Any door not marked as "Regularly used entrance" or "Roof terrace access" is an alarmed exit only

SUSTAINABLE PLACES

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



SUSTAINABLE PLACES

BIM4LEED

BIM4LEED Rating: 3

BIM4LEED

3

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

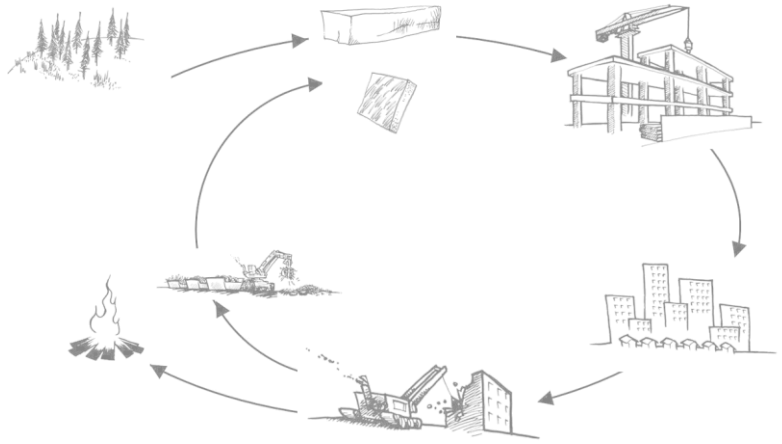
SUSTAINABLE PLACES

Materials and Resources
Building Life-Cycle Impact Reduction

Option 4. Whole Building Life Cycle Assessment

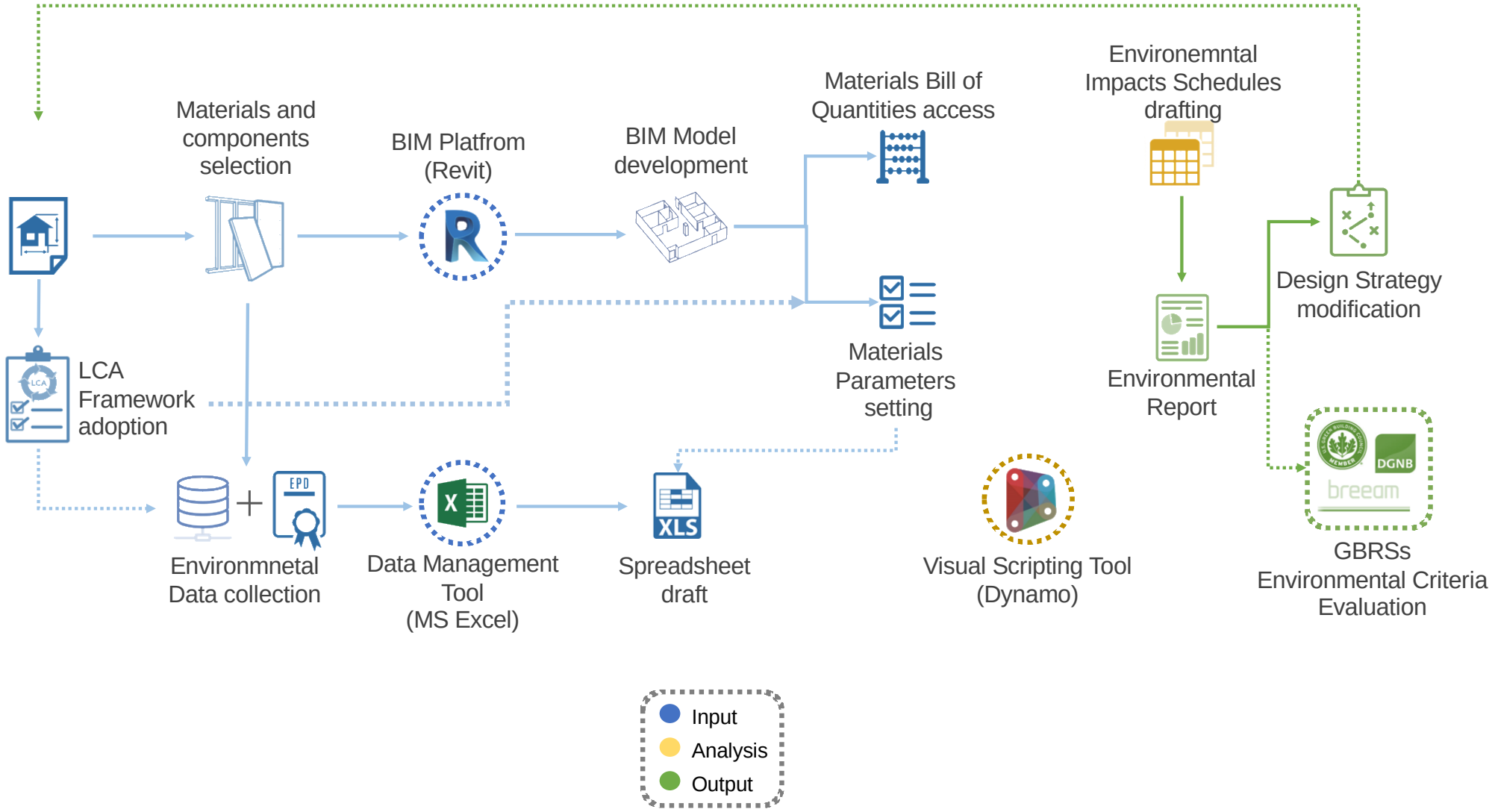
Requirements

Demonstrate reduced environmental effects during initial project decision-making



SUSTAINABLE PLACES

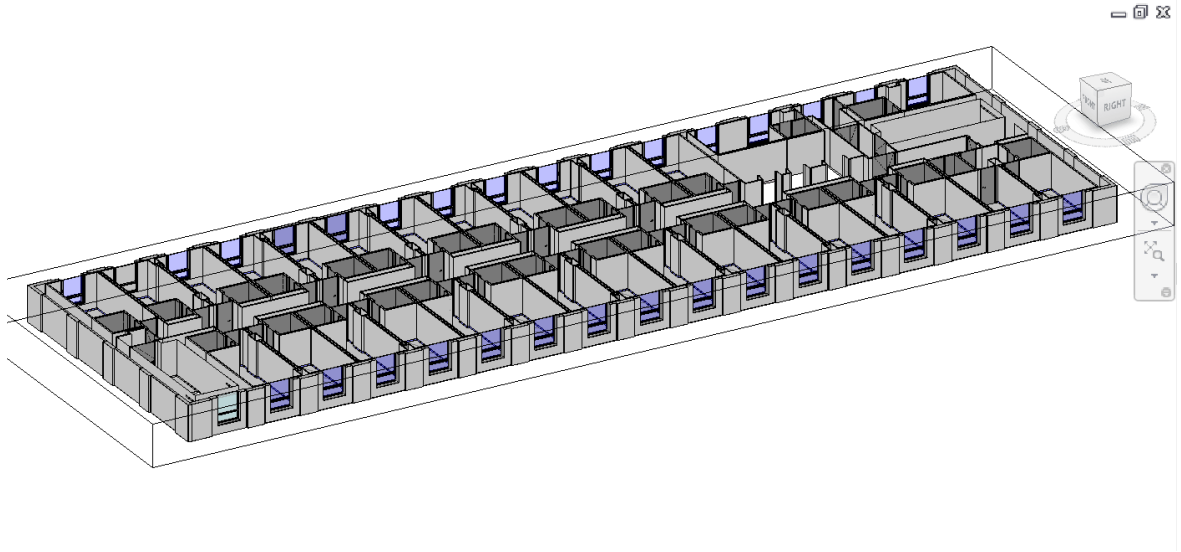
How can I calculate LCA?



SUSTAINABLE PLACES

How can I calculate LCA?

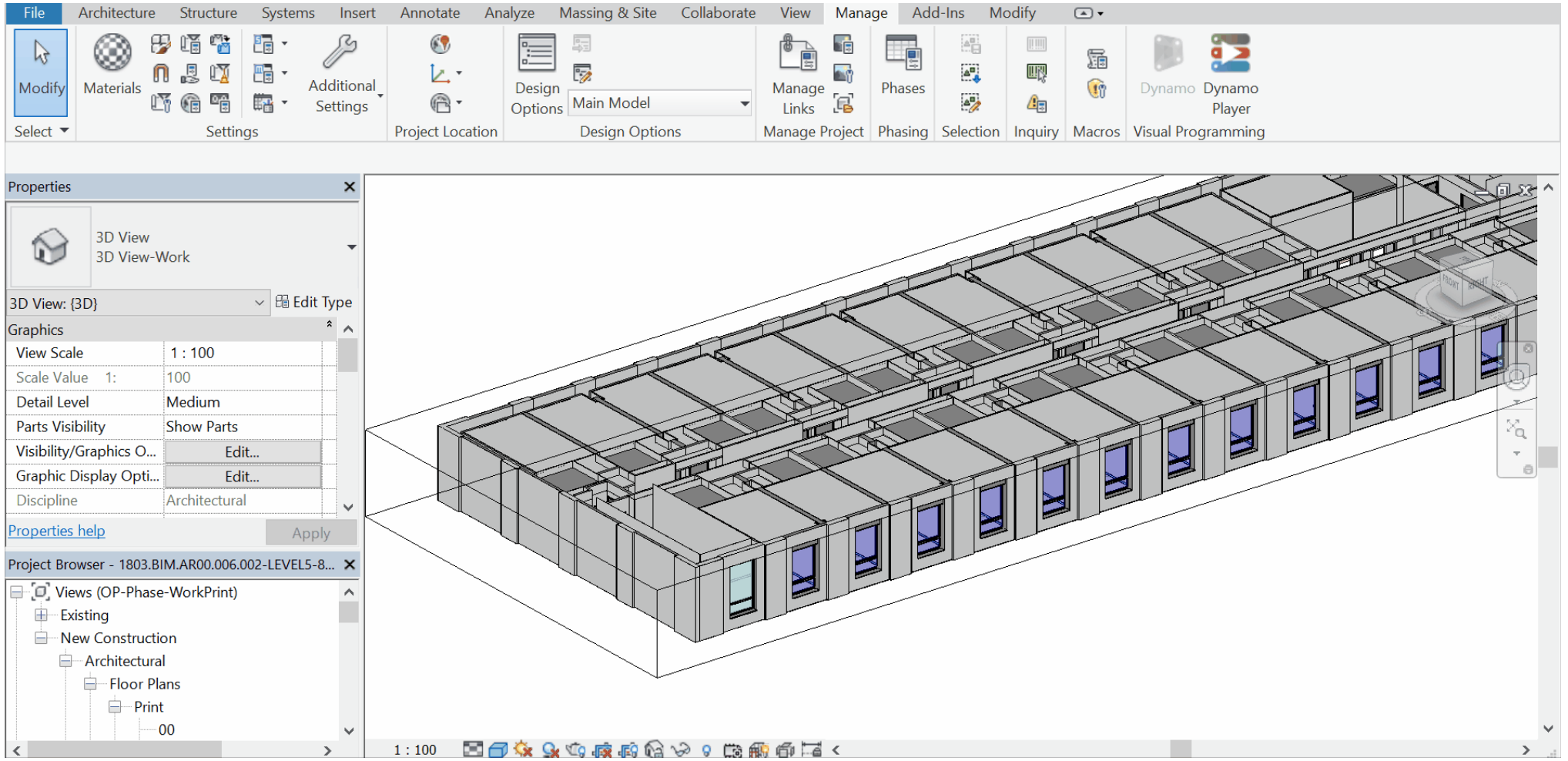
1. Development of the **BIM Model** through Revit:
the external opaque envelope (thus excluding windows) of a multi-storey student residence model floorplan



INPUT

SUSTAINABLE PLACES

How can I calculate LCA?



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

INPUT

SUSTAINABLE PLACES

How can I calculate LCA?

Materials Environmental Data.xls

Material Name	Material Type	Other Info	LCA Modules (e.g. A1-A3)			Functional Unit	Service Life	Source
			LCA Indicator (e.g GWP)	LCA Indicator (e.g. ODP)	LCA Indicator (e.g AP)			
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

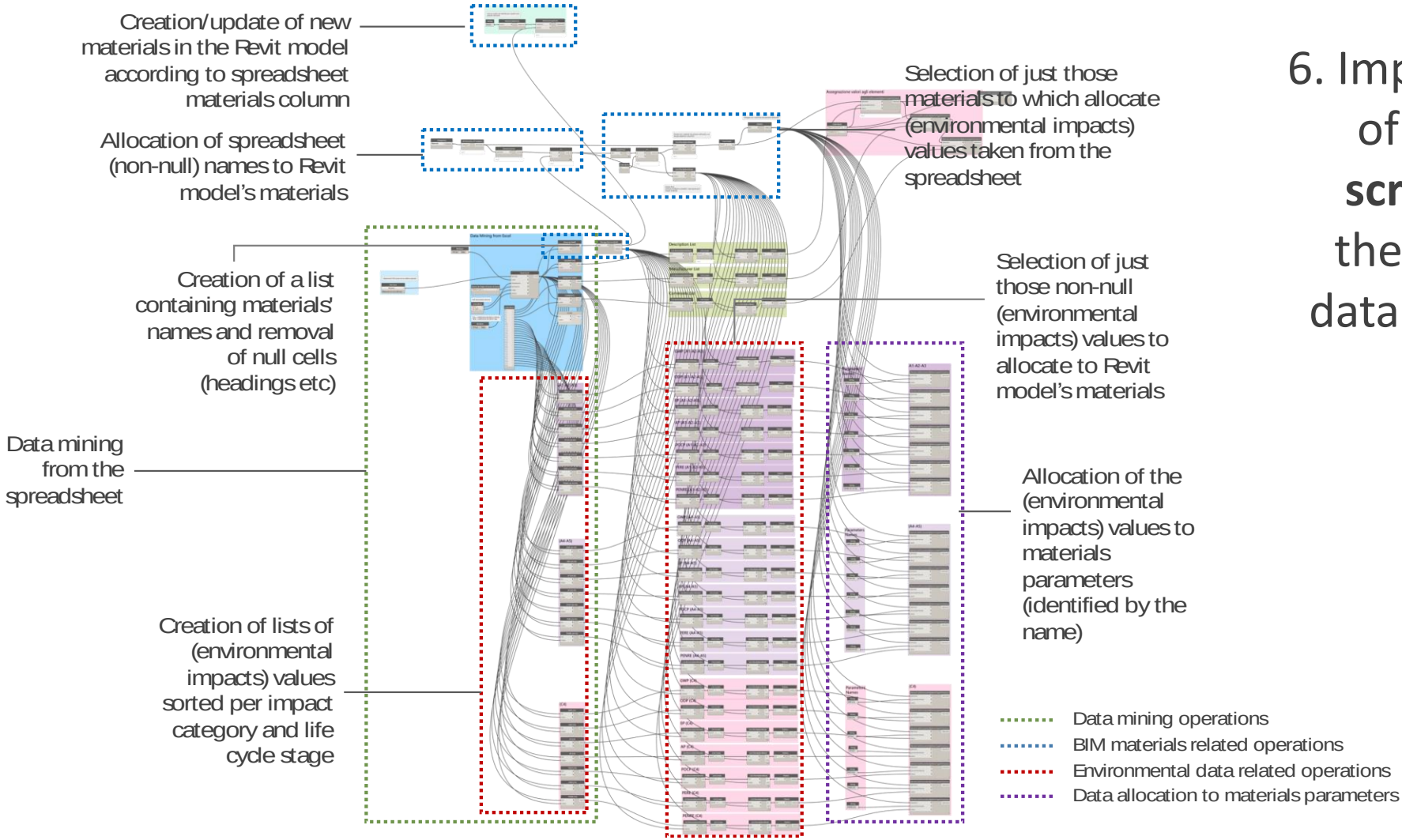
INPUT

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

SUSTAINABLE PLACES

How can I calculate LCA?

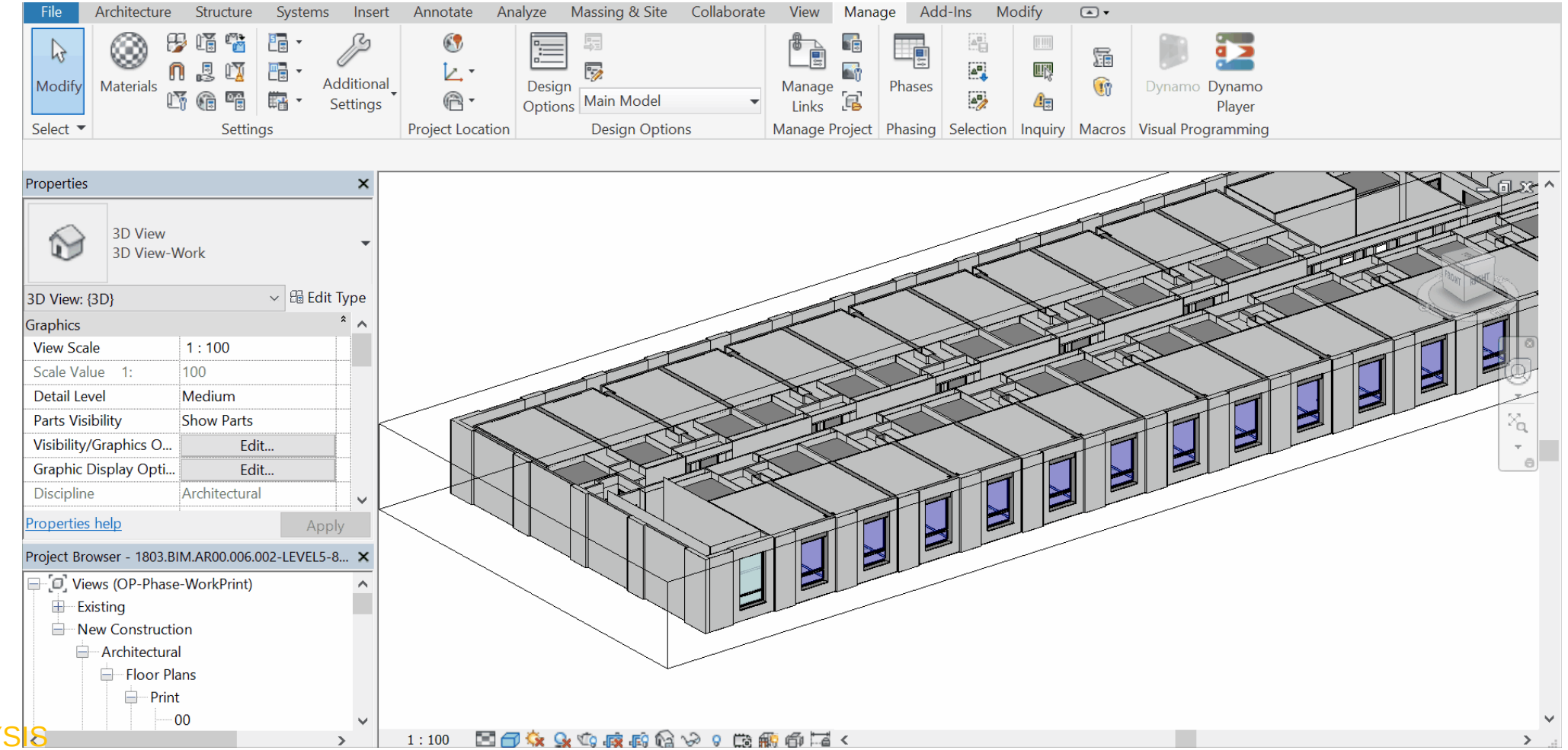


6. Implementation of the **Dynamo script** to import the spreadsheet data into the BIM model :

SUSTAINABLE PLACES

ANALYSIS

How can I calculate LCA?



Script execution effect on the BIM model

SUSTAINABLE PLACES

ANALYSIS

How can I calculate LCA?

A	B	C	D	E	F	G	H	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-100mm-JendyJoss75LRcg								
Envelope	MX-SubstructurePlastboard-RockWool50	13.49 m³	561.921868	0.000019	0.299692	3.746146	0.486999	786.690615
Envelope	PB-CalciumSilicate-Sheet	2.16 m³	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-120mm-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 m³	2072.596378	0.000025	0.675941	5.5746	0.571539	3283.36312
WE.PS-174mm-JendyJossE150LR								
Envelope	MX-SubstructurePlastboard-RockWool70	19.17 m³	1286.18875	0.000043	0.685967	8.574592	1.114697	1800.66425
Envelope	PB-CalciumSilicate-Sheet	3.07 m³	5813.376307	0.000032	1.51217	8.27022	0.50867	9550.54679
		22.24 m³	7099.565057	0.000075	2.198137	16.844812	1.623367	11351.2110
WE.PS-220mm-JendyJoss								
Envelope	MX-SubstructurePlastboard-RockWool70	7.21 m³	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	1294.49241
		7.62 m³	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)

SUSTAINABLE PLACES

ANALYSIS

BIM4LEED Rating: 4

BIM4LEED

4 

You can use the
BIM Authoring Tool basic
commands to verify it

SUSTAINABLE PLACES

Material and Resources
Building life-Cycle Impact Reduction

BIM4LEED

SUSTAINABLE PLACES

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

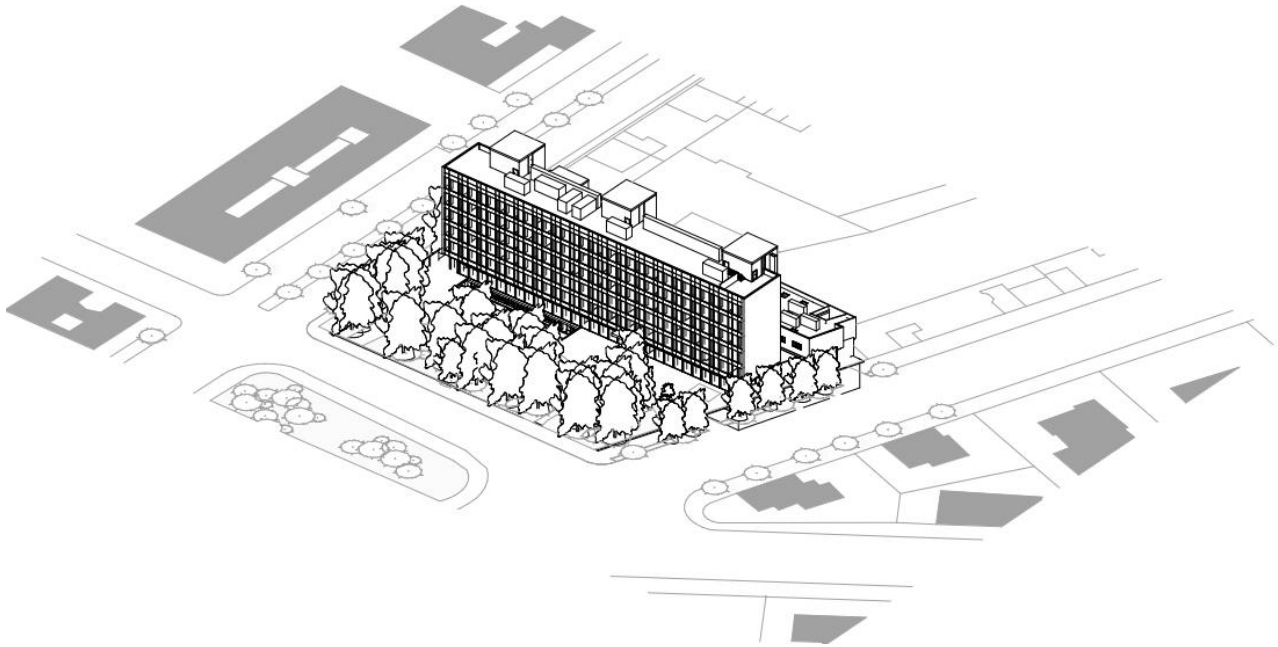
Percentage of completed project surface area reused	Points BD+C	Points BD+C (Core and Shell)
25%	2	2
50%	3	3
75%	4	5

Building life-Cycle Impact Reduction

BIM4LEED

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)



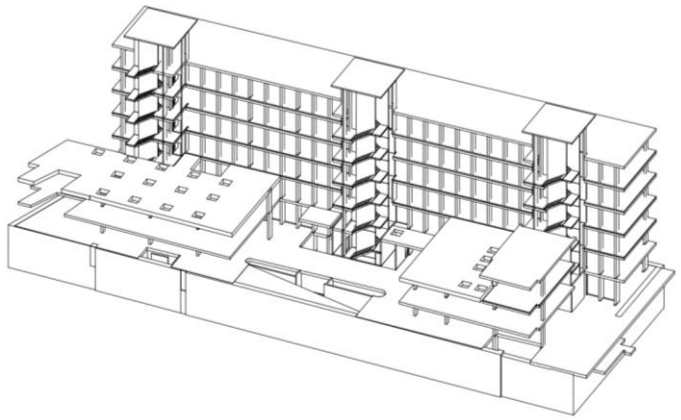
SUSTAINABLE PLACES

Building life-Cycle Impact Reduction

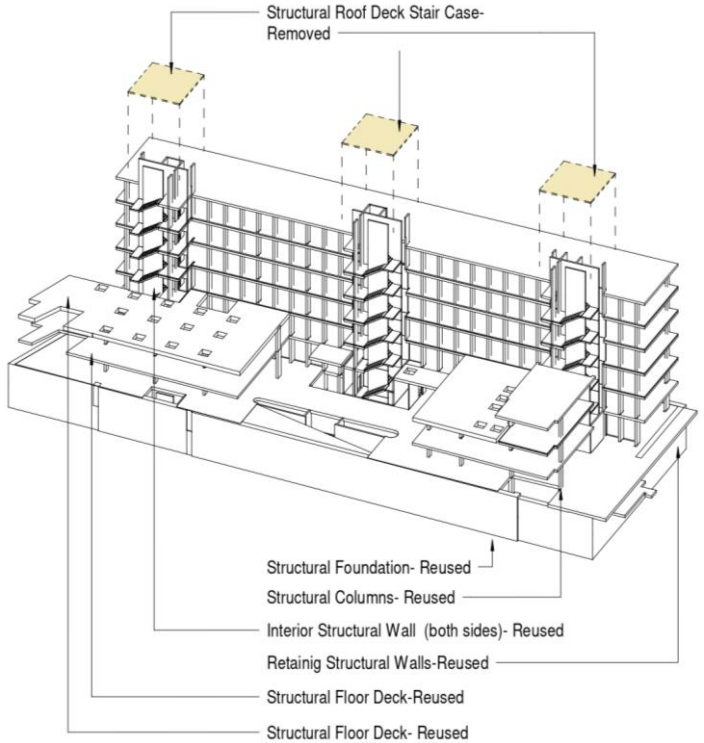
BIM4LEED

- Set phases and discipline in the Revit model

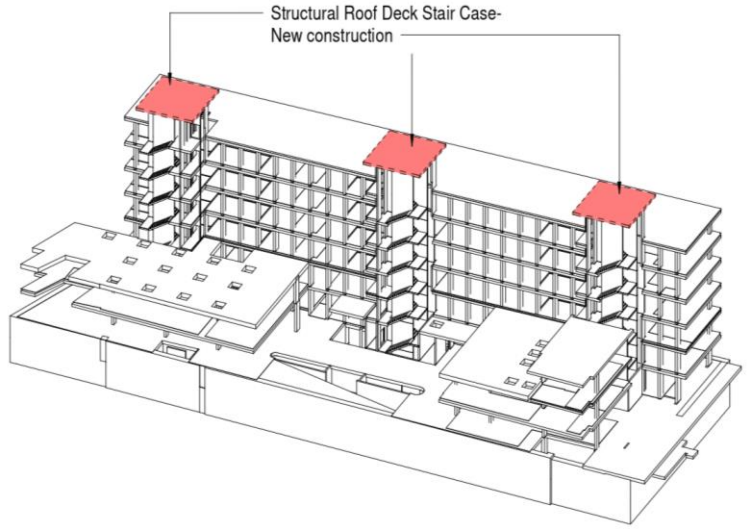
EXISTING



DEMO



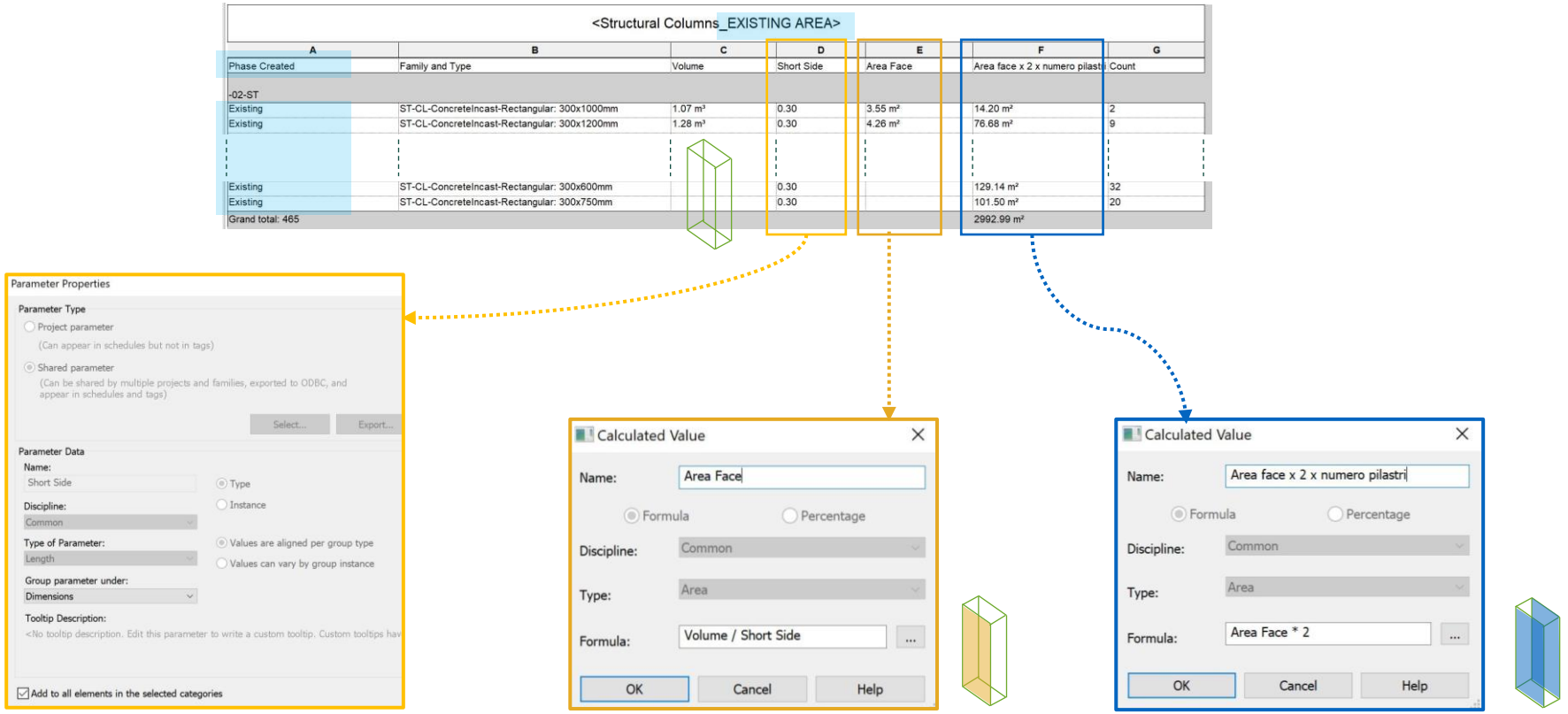
NEW



SUSTAINABLE PLACES

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”



SUSTAINABLE PLACES

Building life-Cycle Impact Reduction

BIM4LEED

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

Revit Schedules

Element	Element Description	Existing Area (sq m)	Reused or Salvaged Area (sq m)		
Structural roof deck		1,760	1,582	+	-
Finished ceiling		5,035	0	+	-
Interior floor finish		11,610	3,836	+	-
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	+	-
Interior structural wall		8,220	8,220	+	-
Foundation		806	806	+	-
Structural floor deck		11,534	11,534	+	-
Total area (sq m)		53,698.57	37,353.54		
Percent building reuse (%)			69.56		

> 50%

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

3 PT

SUSTAINABLE PLACES

BIM4LEED Rating: 5

BIM4LEED

5 

You can use the BIM Authoring Tool with specific LEED plug-in to verify it

SUSTAINABLE PLACES

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.

SUSTAINABLE PLACES

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%**

SUSTAINABLE PLACES

How can I calculate sDA and ASE?

Autodesk
Revit

Autodesk
Insight 360

Lighting
Module

SUSTAINABLE PLACES

How can I calculate sDA and ASE?

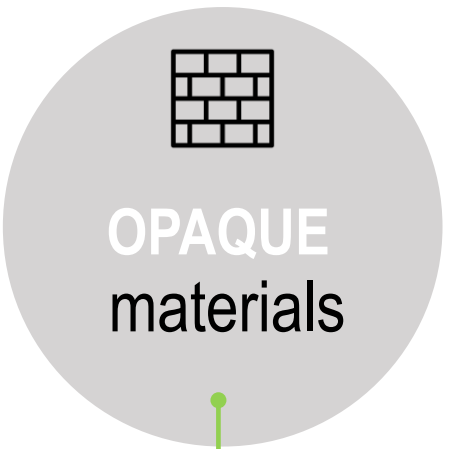
Project location

Real North

Room setting

Colour

Thickness*



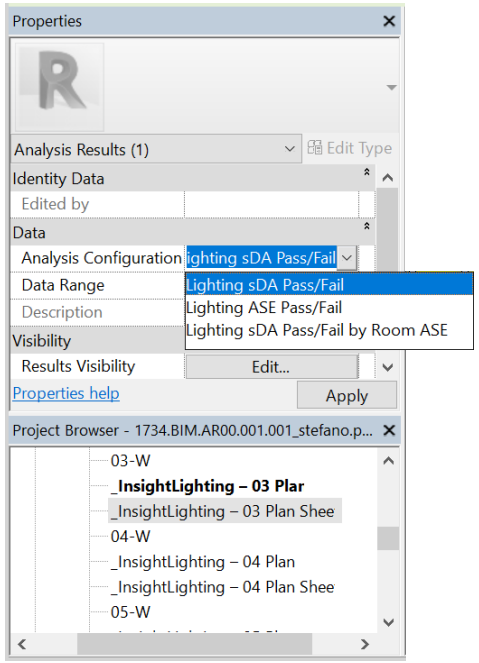
Colour

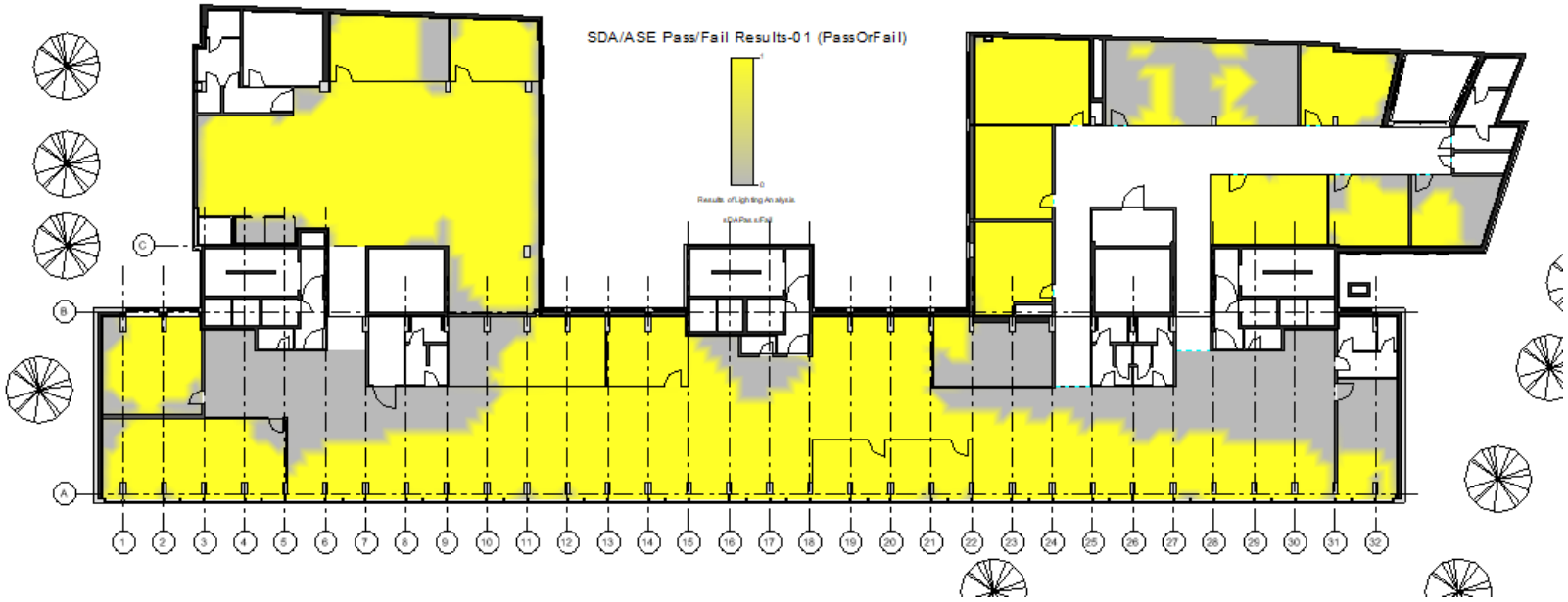
*no more from
Lighting v4.0+

SUSTAINABLE PLACES

How can I calculate sDA and ASE?

Analysis output→ **Plan view**

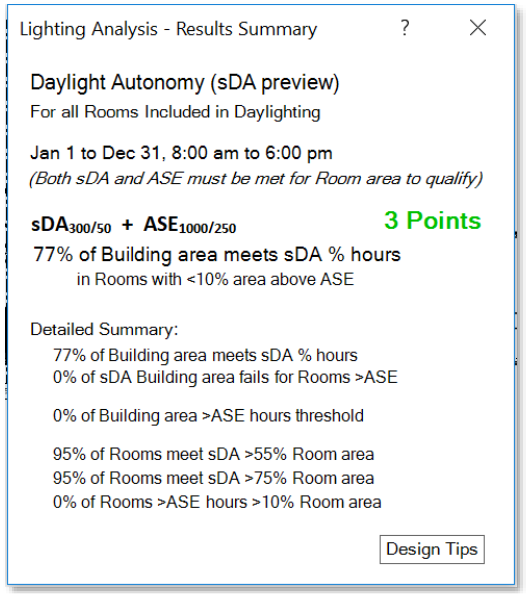




SUSTAINABLE PLACES

How can I calculate sDA and ASE?

Analysis output→ **Schedule**



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

B	C	D	E	F	G	H	I	J	K
				sDA 300/50		ASE 1000/250		sDA/ASE	
Nome	Numero	Area	Include In Daylighting	%	Points	%	Pass	%	Points
Meeting	-1.03	33 m²	☑						
Meeting	0.01	249 m²	☑	100	3 pt	4	Yes	100	3 pt
Reception	0.02	105 m²	☑	94	3 pt	1	Yes	94	3 pt
Zona Ristoro	0.03	134 m²	☑	98	3 pt	1	Yes	98	3 pt
Meeting	0.04	72 m²	☑	100	3 pt	16	Yes	100	3 pt
Office	0.39	12 m²	☑	100	3 pt	90	No	0	none
Meeting	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 m²	☑	89	3 pt	25	No	0	none
Office	1.02	50 m²	☑	83	3 pt	0	Yes	83	3 pt
Meeting	1.01	36 m²	☑	62	2 pt	8	Yes	62	2 pt
Meeting	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
Meeting	1.40	57 m²	☑	75	3 pt	8	Yes	75	3 pt

F	G	H	I	J	K
sDA 300/50		ASE 1000/250		sDA/ASE	
%	Points	%	Pass	%	Points
100	3 pt	4	Yes	100	3 pt
94	3 pt	1	Yes	94	3 pt
98	3 pt	1	Yes	98	3 pt

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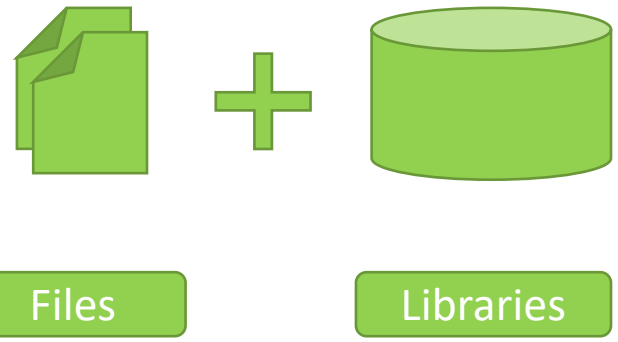
Next Step

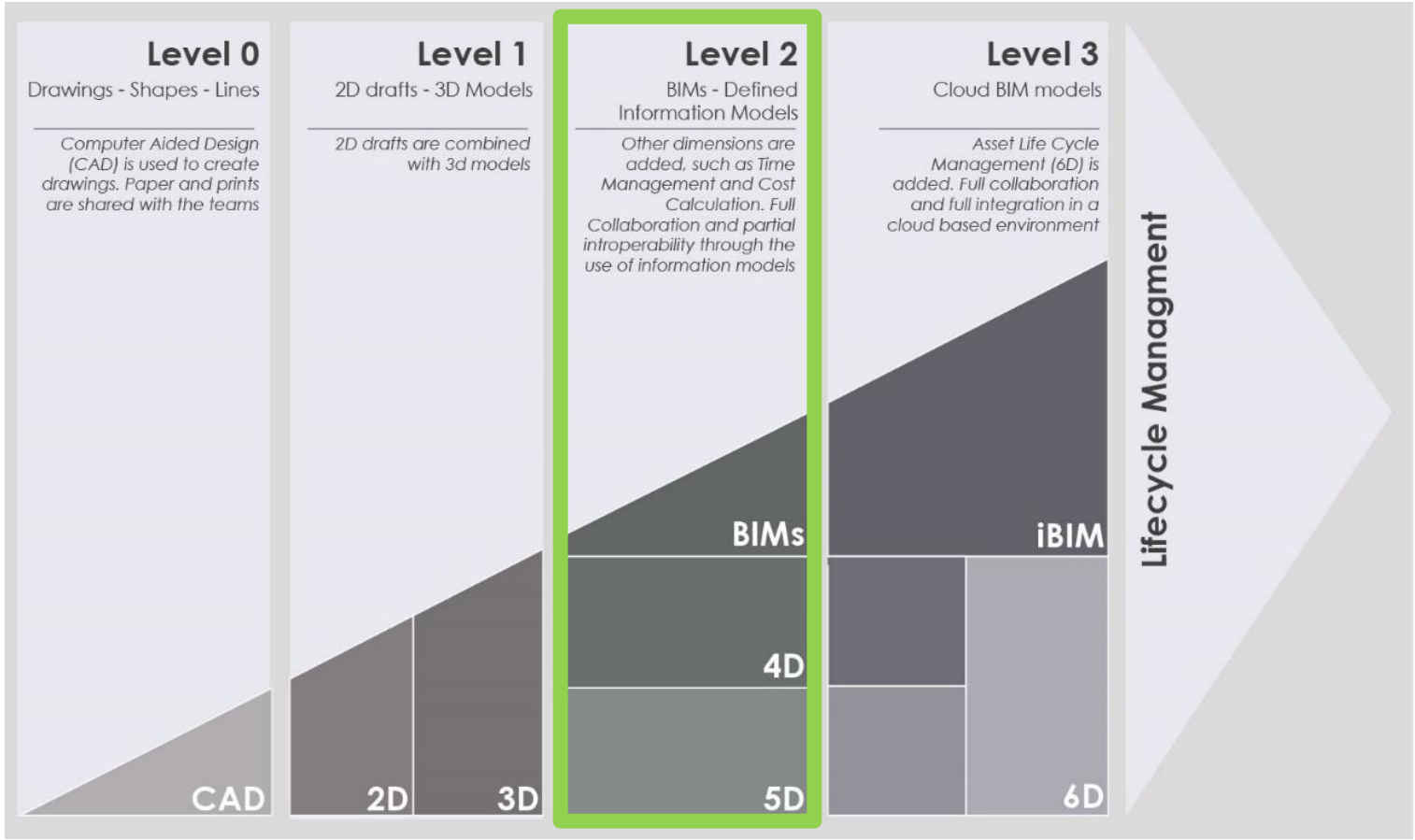
structure the BIM data to insert them automatically in the LEED Online Spreadsheet

SUSTAINABLE PLACES

Currently

All the previous methodology was under BIM level 2 maturity level





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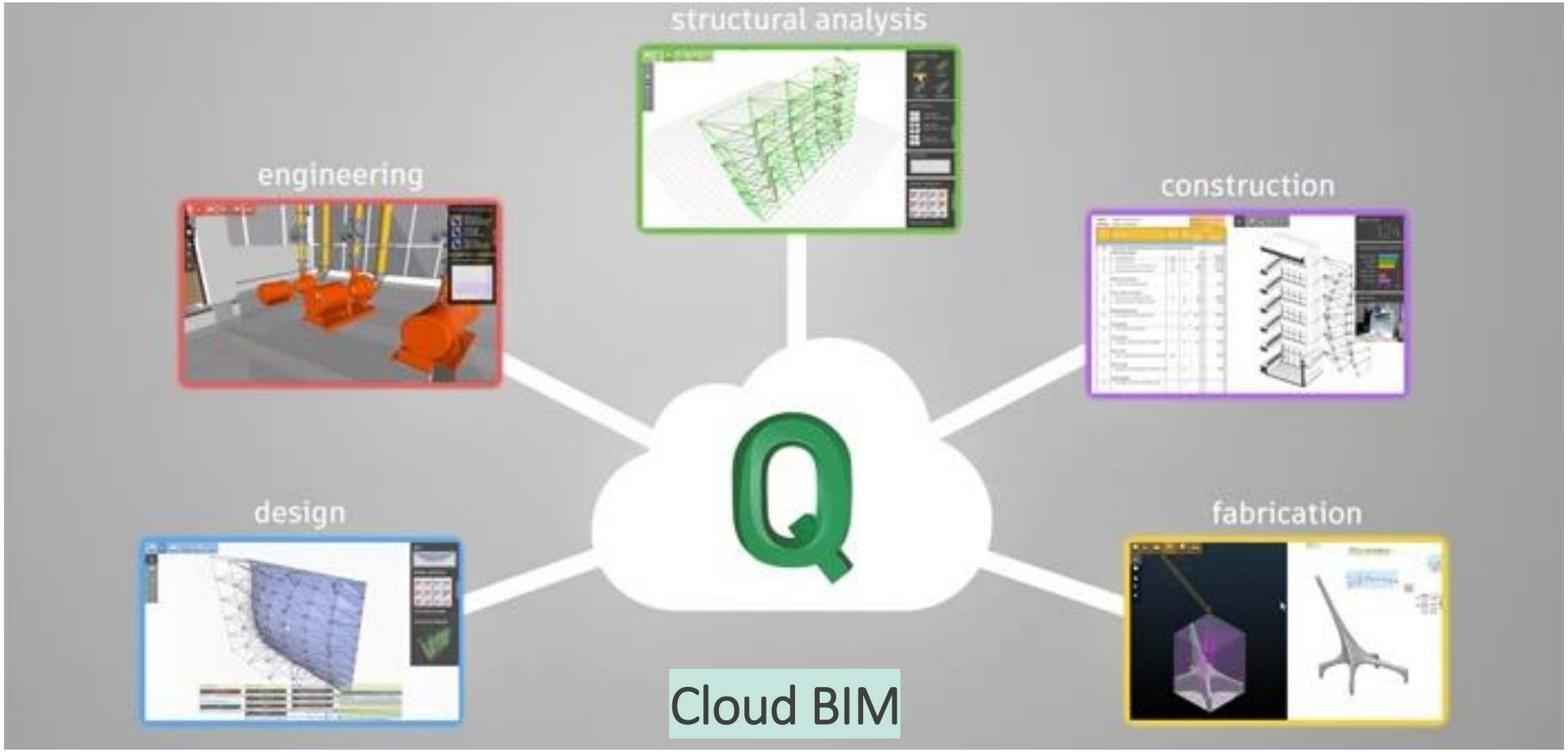
The future of interoperability



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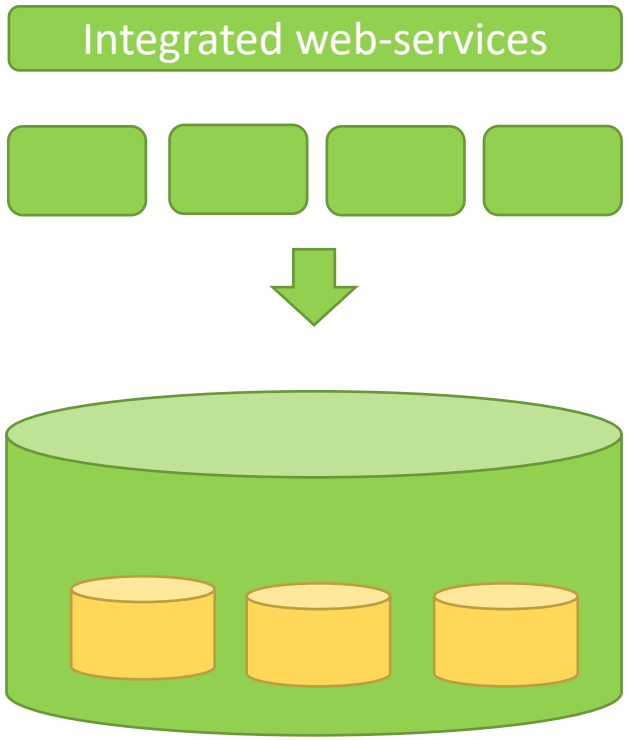
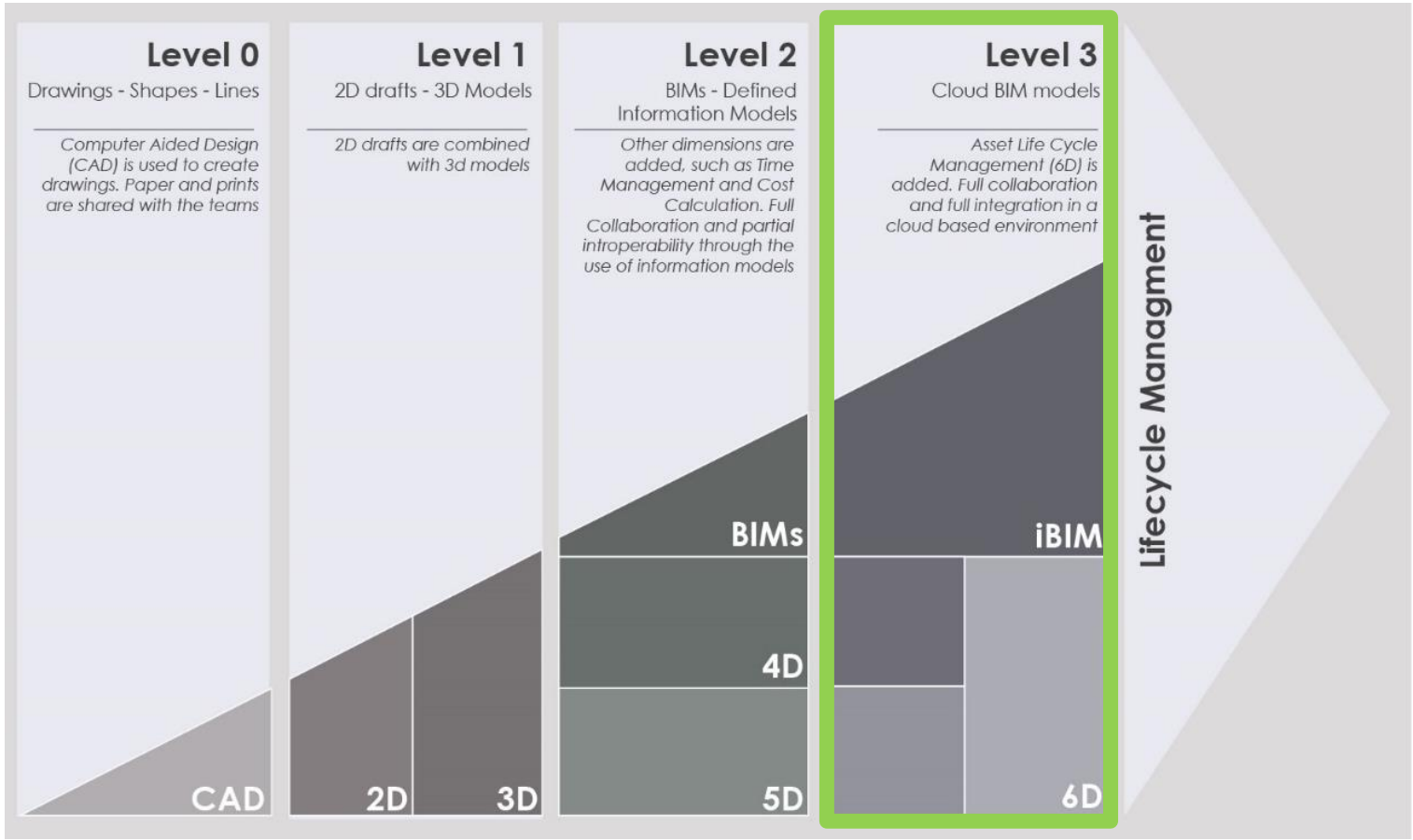
The future

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





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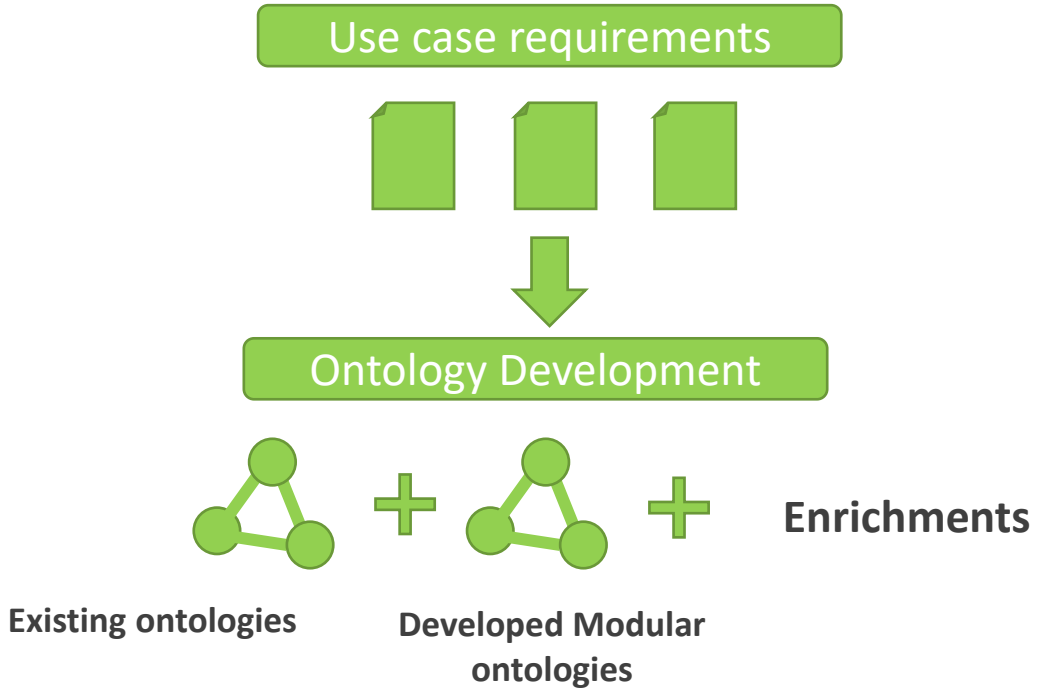
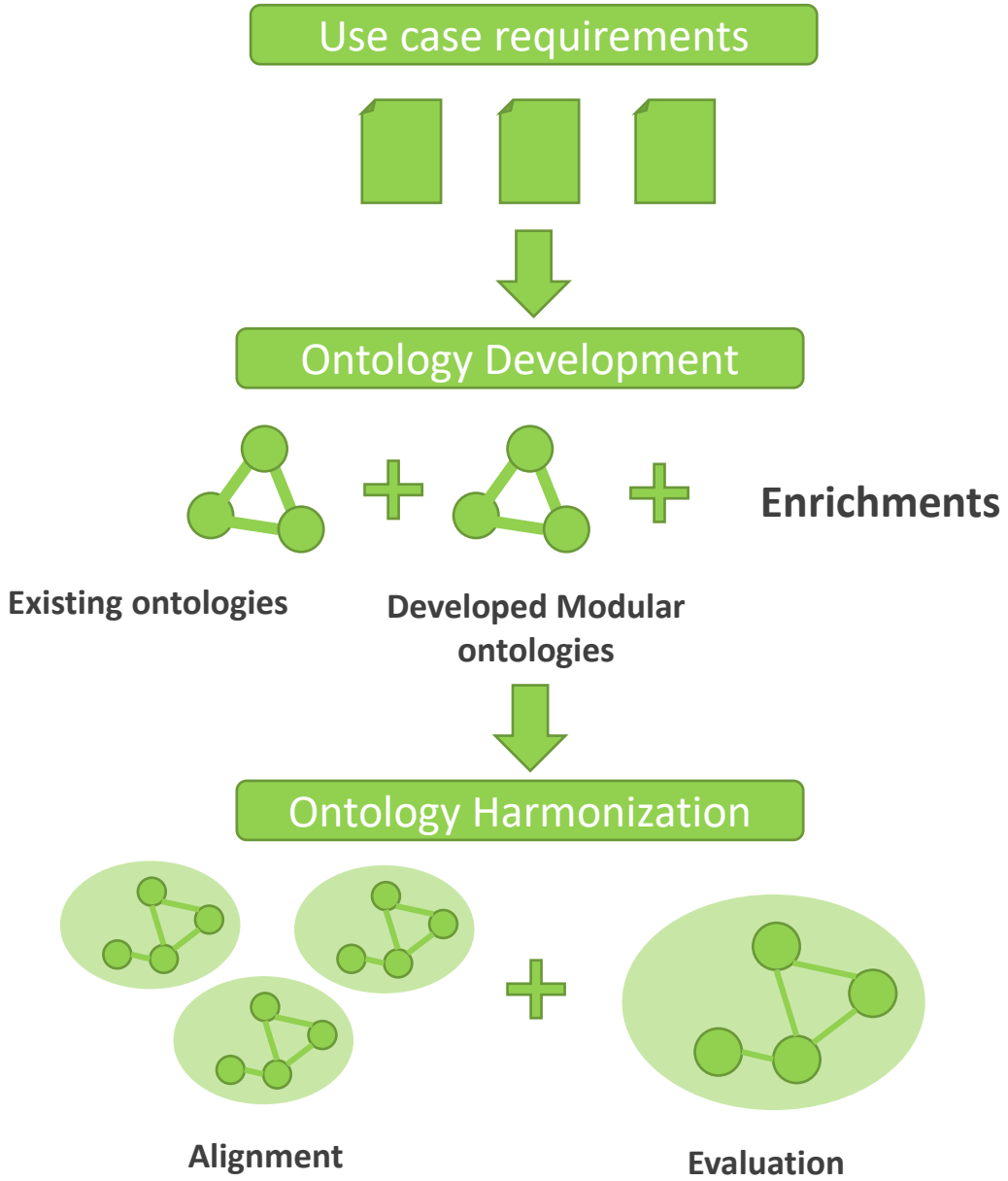
Ontologies & Semantic web

Ontologies & Semantic web



Ontologies & Semantic web



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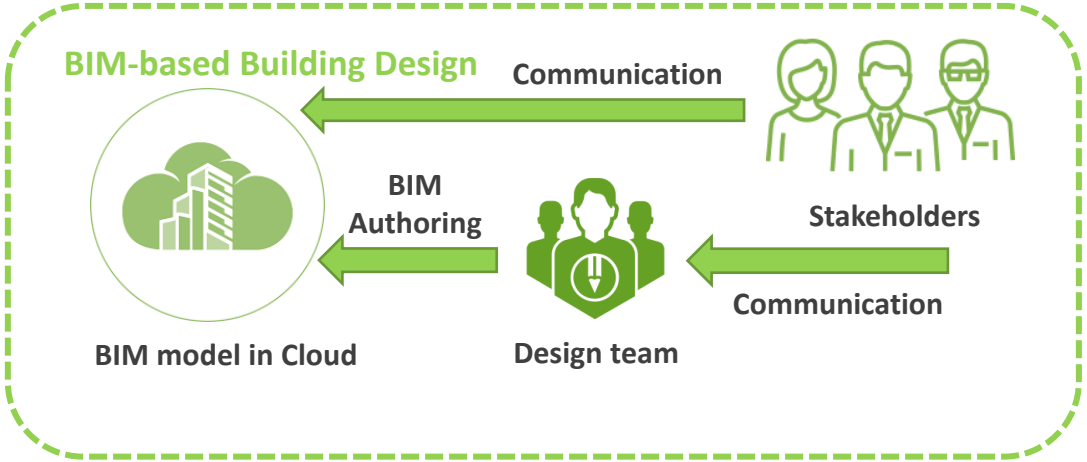
Reasons to develop an ontology

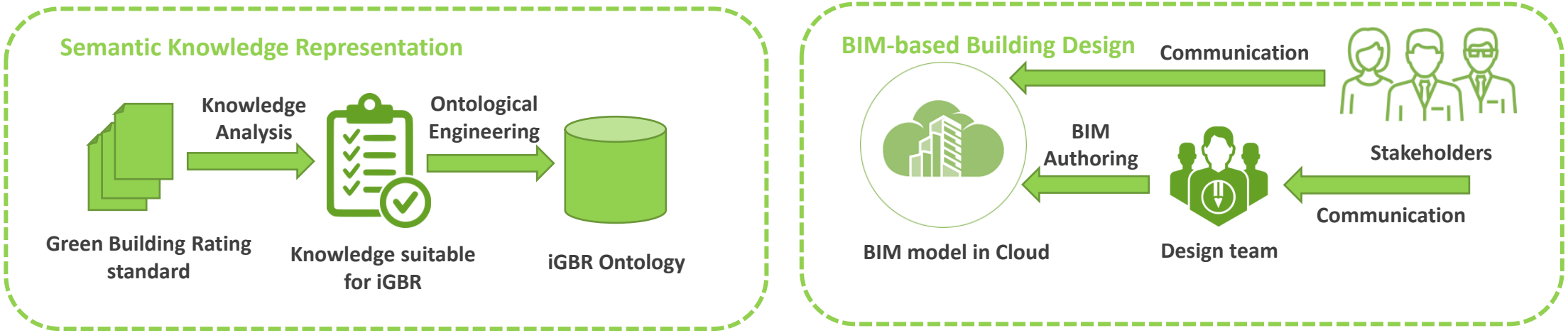
- Create a common understanding of information among people
- Enable reuse of domain knowledge
- Make a domain's main assumptions explicit
- Separate domain knowledge from the operation knowledge
- Analyze domain knowledge

iGBR framework - Example



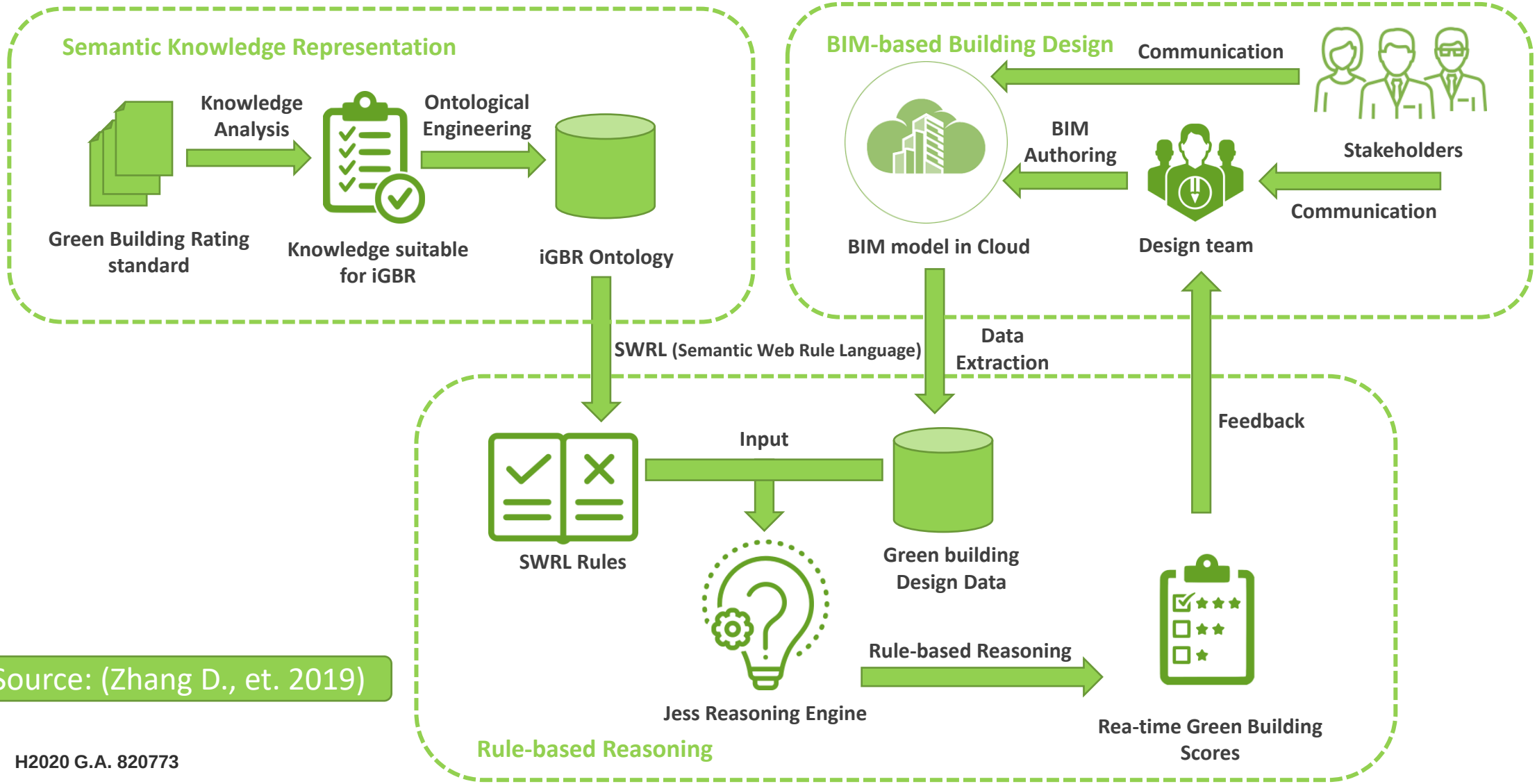
Source: (Zhang D., et. 2019)

iGBR framework - Example



Source: (Zhang D., et. 2019)

iGBR framework - Example



Source: (Zhang D., et. 2019)

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ifcOWL: Web Ontology Language

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

buildingSMART International

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

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Thank you

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

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