BIMEPD

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ADAPTED SENIOR TRAINING PROGRAM ON BIM METHODOLOGIES FOR THE INTEGRATION OF EPD IN SUSTAINABLE CONSTRUCTION STRATEGIES

2020-1-ES01-KA204-083128

Module 07

Initiation and development of a project with BIM technology through a strategy of environmental impact reduction.

COAMU Colegio Oficial de Arquitectos Región de Murcia

iED institute of Entrepreneurship Development

CTM Centro Tecnológico del mármol, piedra y materiales

Warsaw University of Technology

Bulgarian Green Building Council

cype

Erasmus+

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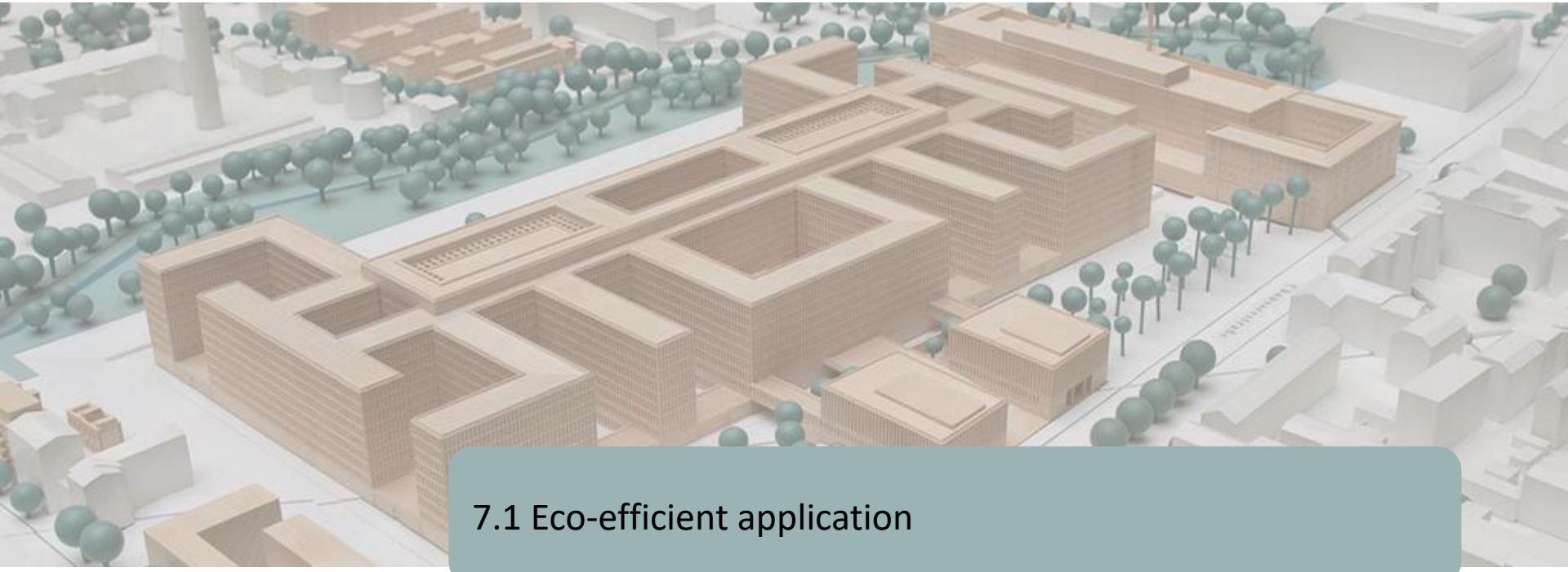

7.1 Eco-efficient application

7.2 Connectivity model

7.3 Workflow model

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7.1 Eco-efficient application

INITIAL APPROACH

OBJECTIVES TO BE DEVELOPED FOR ECO-EFFICIENT IMPLEMENTATION

SCALES OF ACTION

COLLECTION OF ENVIRONMENTAL INFORMATION

CALCULATION ANALYSIS OF EACH STAGE

DATA INTEGRATION IN BIM OBJECTS

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INITIAL APPROACH

Sustainable Development Goals (SDGs) in the construction sector.

In all the goals we have an important responsibility as professionals and as citizens. For the construction sector, we highlight the following:

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INITIAL APPROACH

Sustainable Development Goals (SDGs) in the construction sector.

Many initiatives and changes are needed in many areas. In the building sector we have a great responsibility for the health and well-being of citizens.

We must build with healthy materials and design well in order to ensure optimal comfort and well-being.

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INITIAL APPROACH

Sustainable Development Goals (SDGs) in the construction sector.

Energy is central to almost every major challenge and opportunity facing the world today. Whether for jobs, security, climate change, food production or raising incomes. Universal access to energy is essential.

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INITIAL APPROACH

Sustainable Development Goals (SDGs) in the construction sector.

The construction sector must face the challenge of improving the quality of life in cities, without harming the environment, or minimising its impact.

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INITIAL APPROACH

Sustainable Development Goals (SDGs) in the construction sector.

The goal of sustainable consumption and production is to do more and better things with fewer resources. It is about creating net gains from economic activities by reducing resource use, degradation and pollution, while achieving a better quality of life.

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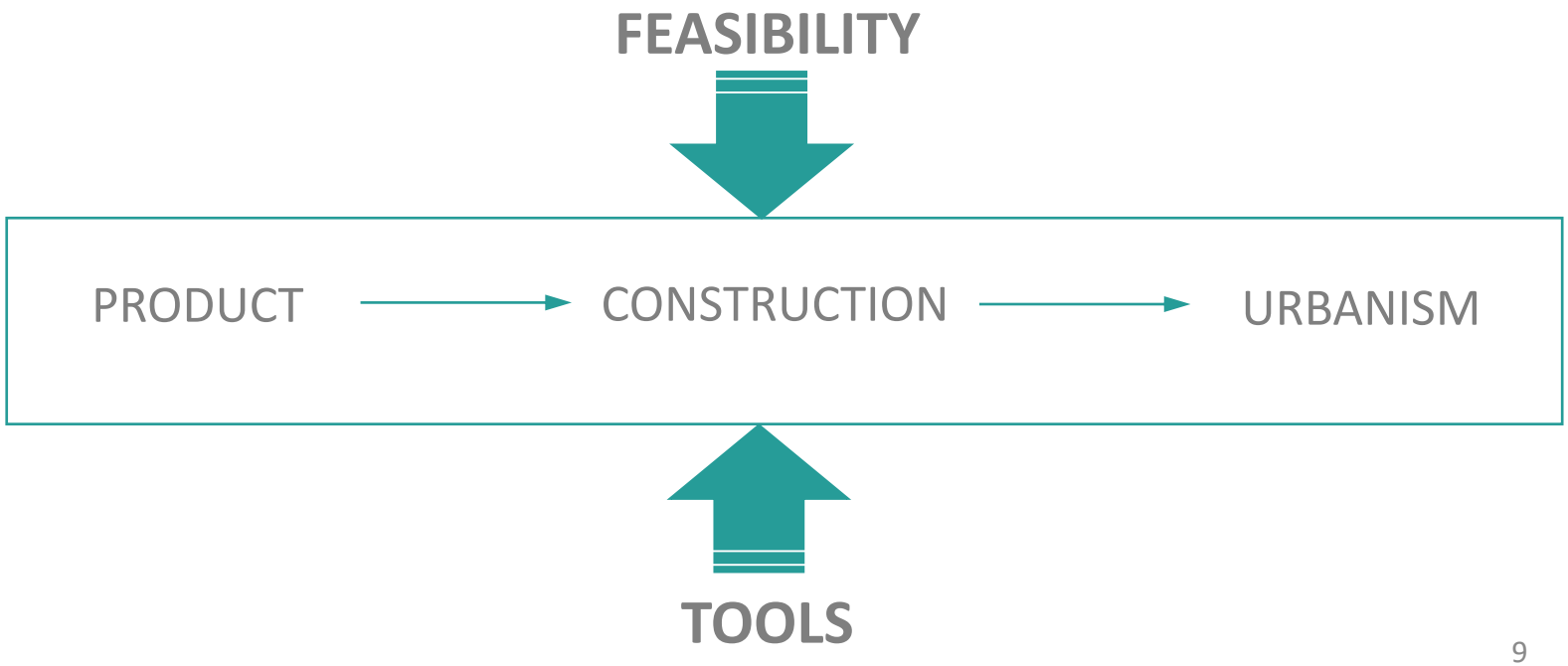
INITIAL APPROACH

Therefore, in line with the SDGs, how should the feasibility for the generation of sustainable buildings and territories be addressed from the point of view of eco-efficiency at the product and building scale in urban developments and rehabilitations through the use of IT applications and tools?



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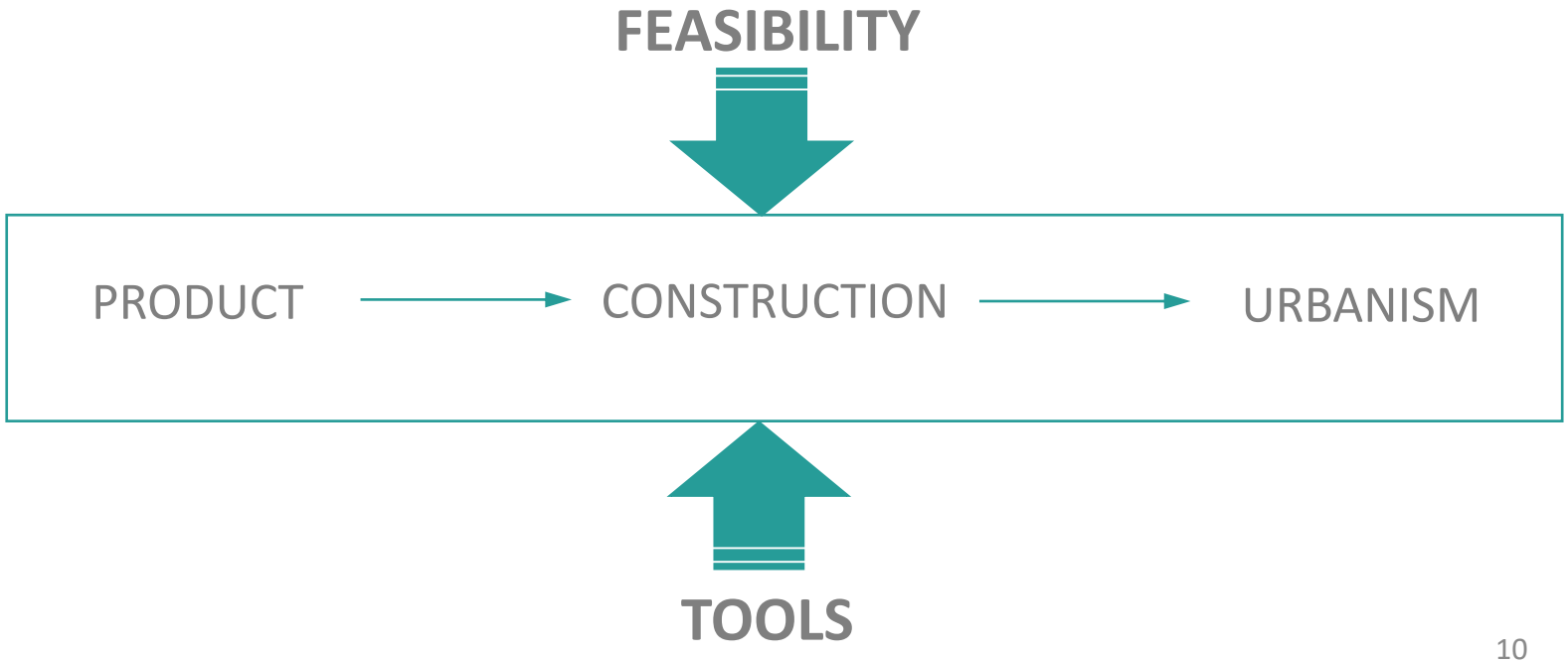
INITIAL APPROACH

Therefore, it highlights the concepts of:

- viability to generate sustainable buildings and territories;
- the three scales of action: at product level, building level in construction and urban and territorial level in urban planning;
- and all of this with the support of new technologies.



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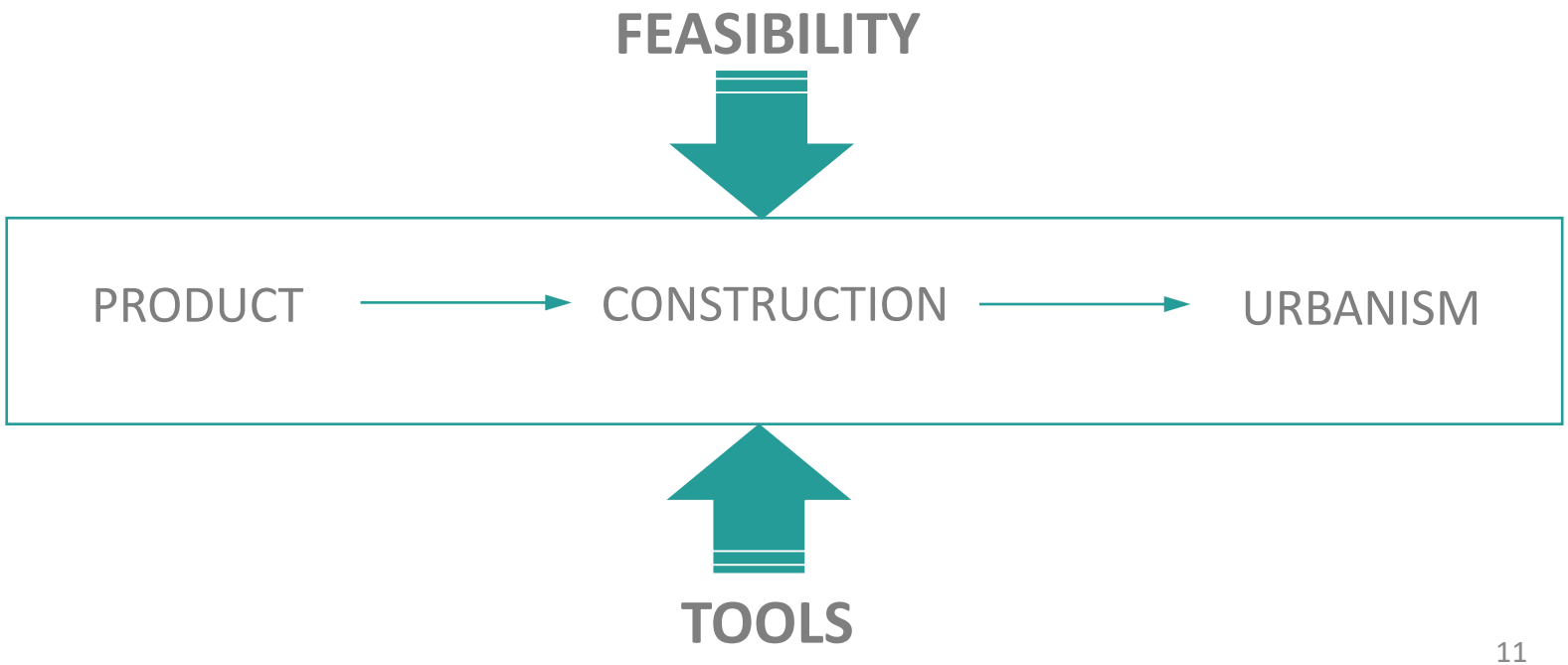
INITIAL APPROACH

The application of BIM technologies in society will contribute to an easier and more complete control of the environmental impact of constructions, as well as to the improvement of the quality and management of buildings throughout their life cycle.



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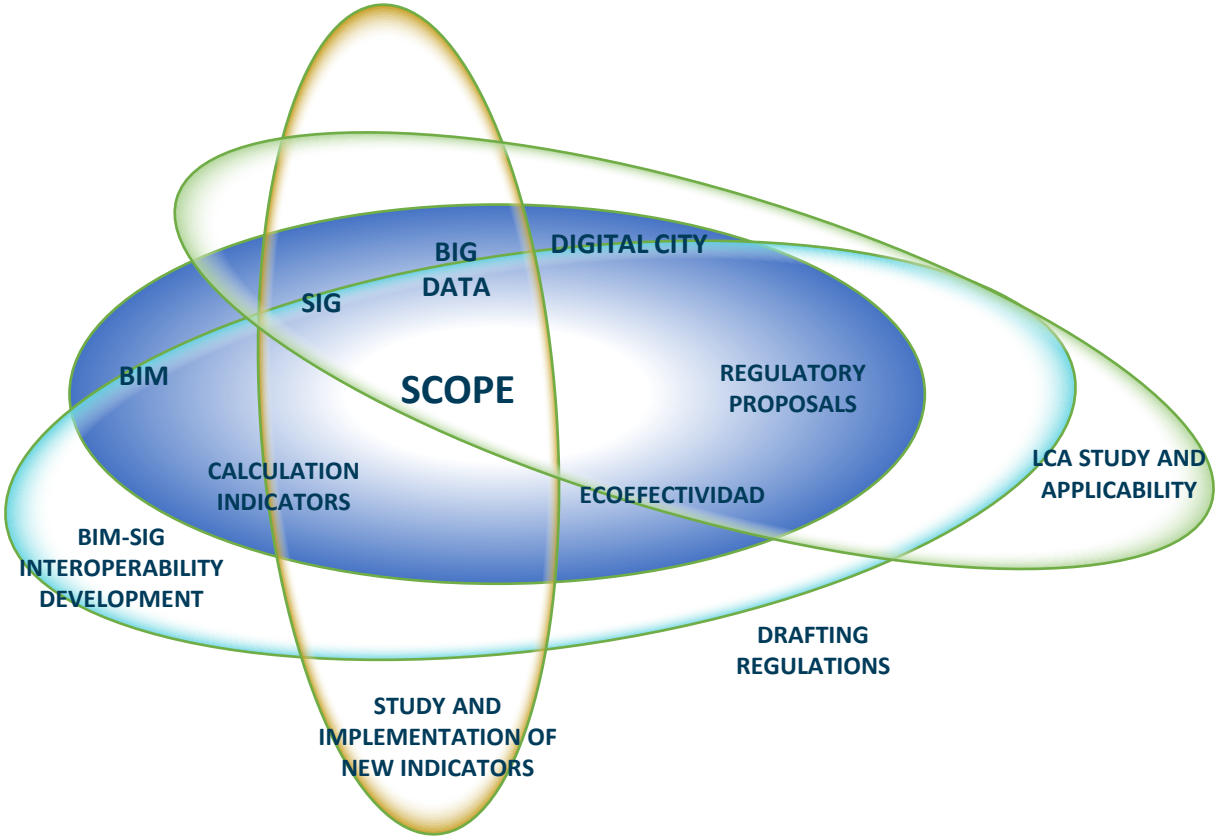
OBJECTIVES TO BE DEVELOPED FOR ECO-EFFICIENT IMPLEMENTATION

At present, there are a number of issues that need to be implemented in the construction sector in the coming years from the point of view of eco-efficiency in the use of material resources, focusing on the following objectives:



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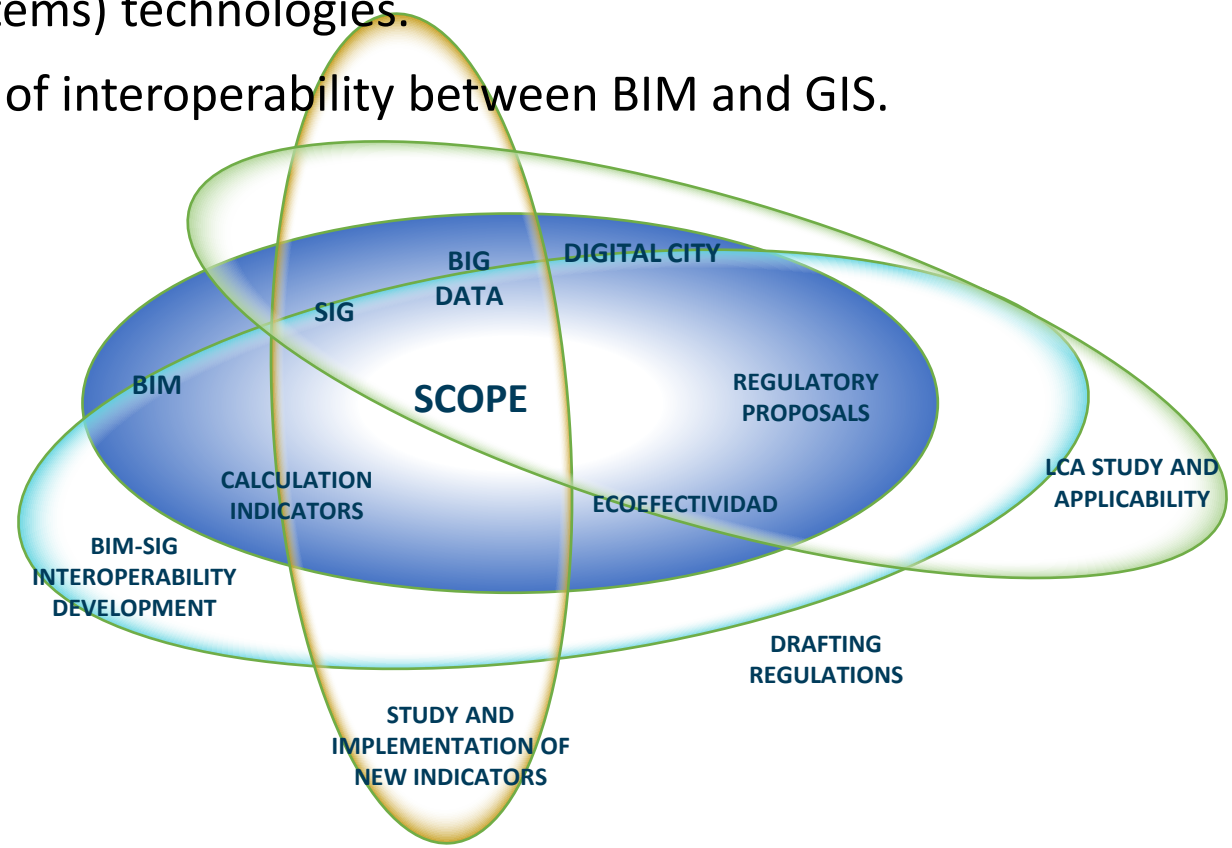
OBJECTIVES TO BE DEVELOPED FOR ECO-EFFICIENT IMPLEMENTATION

1. Common and easily understandable criteria for architecture and urban planning professionals focused on sustainability criteria in building.

2. Common calculation tools and software with BIM and GIS (Geographic Information Systems) technologies.

3. Development of interoperability between BIM and GIS.



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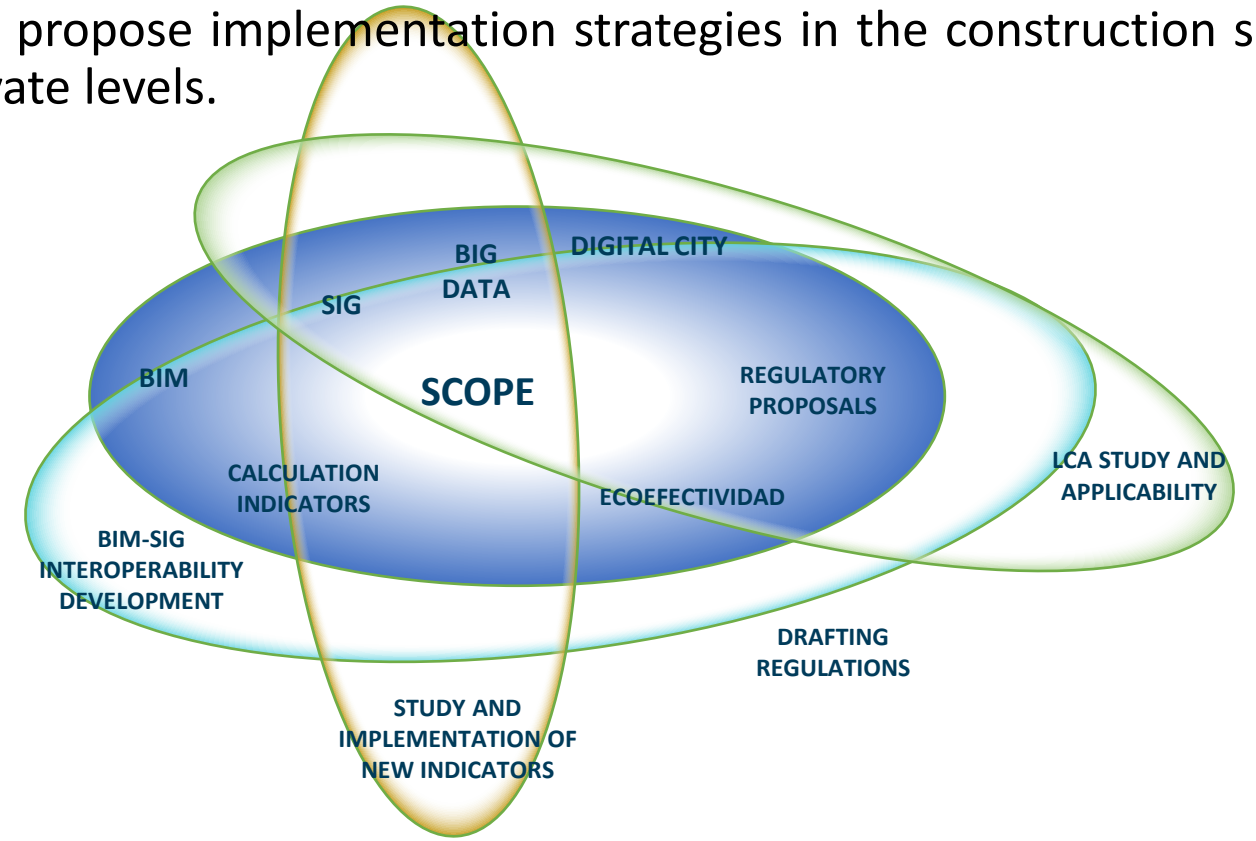
OBJECTIVES TO BE DEVELOPED FOR ECO-EFFICIENT IMPLEMENTATION

4. Homogeneous regulatory framework at European level with regard to BIM and sustainable building.

5. Circular economy based on the construction of digital cities and Big Data.

6. Establish and propose implementation strategies in the construction sector at all public-private levels.



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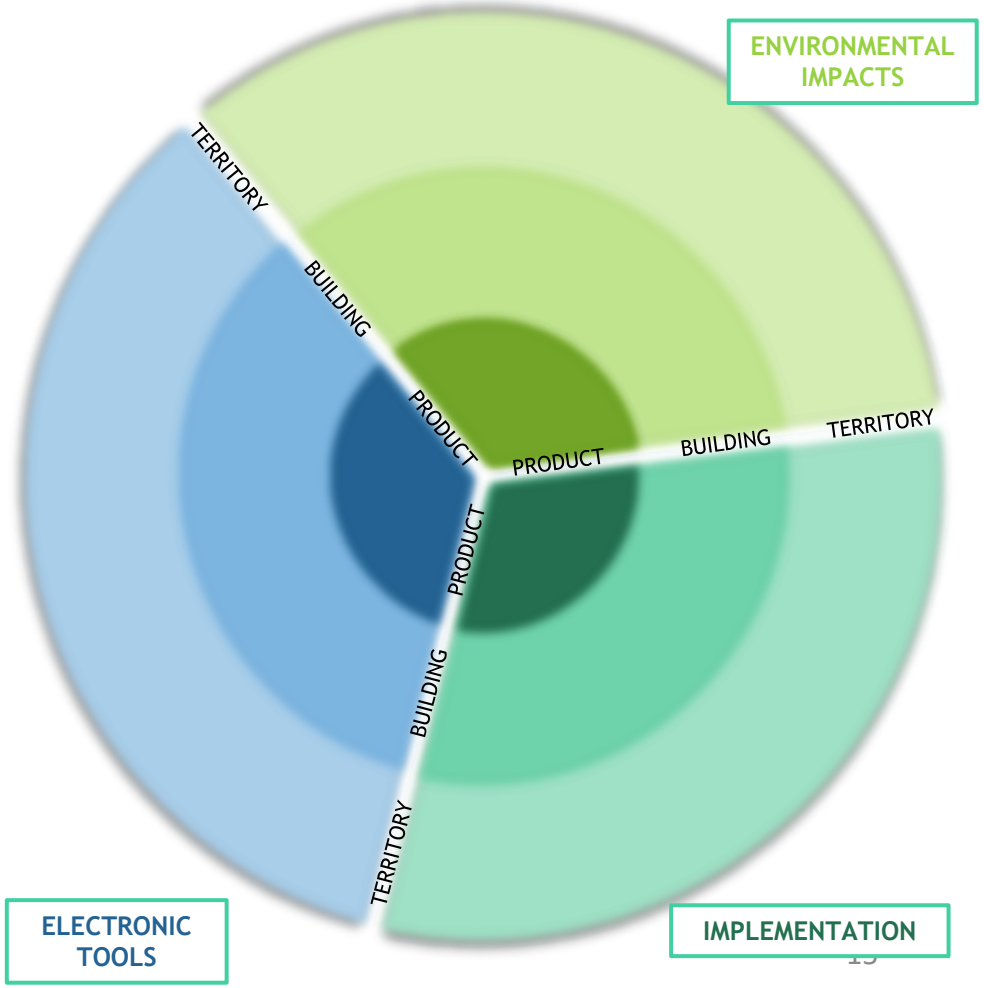
SCALES OF ACTION

This initial approach to eco-efficiency applied to the construction sector should focus on the following scales:

- Product
- Building
- Territory



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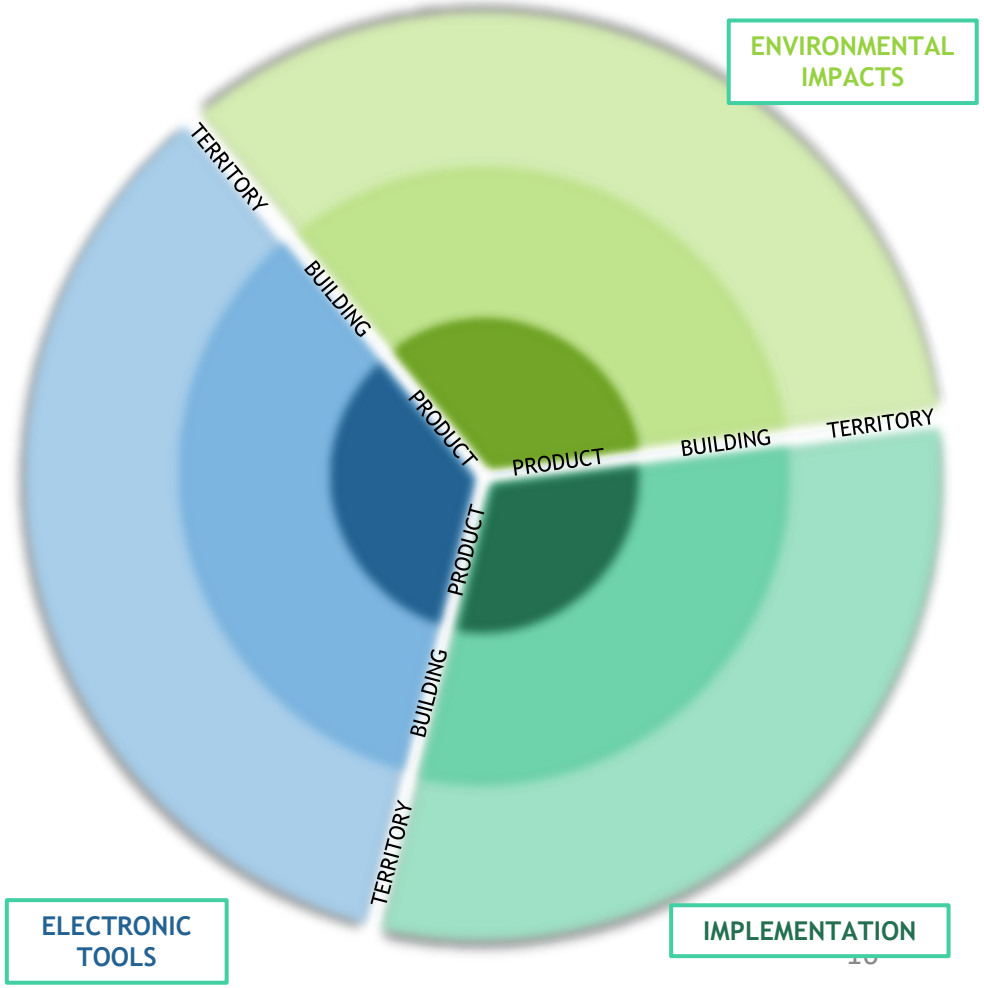
SCALES OF ACTION

All this, focused on the knowledge of these 3 scales (product, building and territory) on:

- Environmental impacts.
- Implementation of electronic tools and environmental impact studies.
- Electronic tools.



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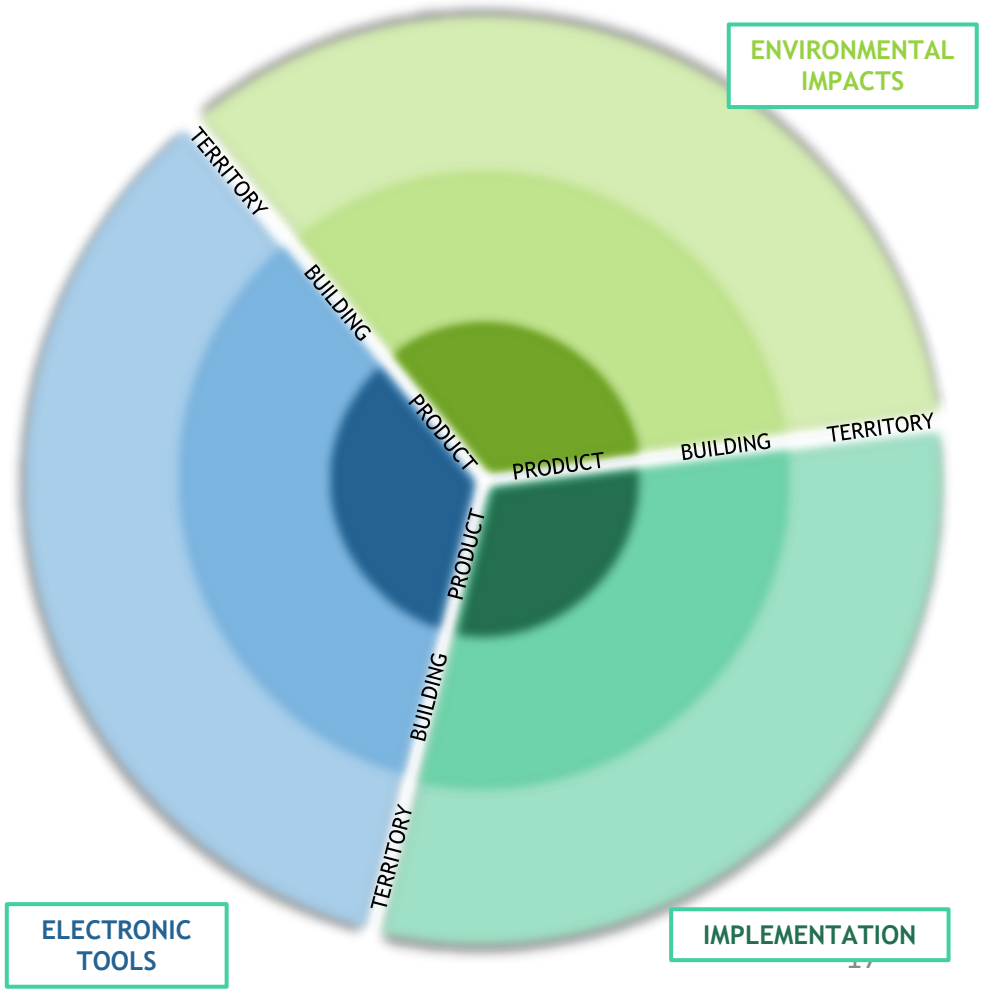
SCALES OF ACTION

The construction sector must increase its knowledge in this aspect by increasing the number of EPDs to be carried out. These EPDs will help to gain a better understanding of the impact of buildings, from this point, in turn, at the territorial level.

Of course, the development and use of electronic tools at each and every one of these scales will be necessary for the implementation of the Sustainable Development Goals in the building sector.



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COLLECTION OF ENVIRONMENTAL INFORMATION

Environmental Product Declarations (EPD) allow manufacturers to transfer reliable, accurate and verifiable information on the environmental aspects of the products they manufacture, which facilitates the environmental certification of buildings and their use in labels such as BREEAM, LEED, GREEN, etc. or for their application in the calculation methodology set out in EN 15978 *Sustainability in construction. Assessment of the environmental performance of buildings. Calculation methods.*

The demand for this type of specific environmental information by developers, builders and specifiers has been growing exponentially in recent years, to the point that, in the short term, having it available from manufacturers will be practically an essential requirement to avoid being displaced from the market.

7.1 Eco-efficient application

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IMPACTOS AMBIENTALES

Parámetros	Etapa de Product	Etapa de Proceso de Construcción		Etapa de Uso							Etapa de Fin de Vida				D Potencial de Reutilización, Recuperación y Reciclaje
	A1 / A2 / A3	A4 Transporte	A5 Instalación	B1 Uso	B2 Mantenimiento	B3 Reparación	B4 Sustitución	B5 Rehabilitación	B6 Uso de energía en Servicio	B7 Uso de Agua en Servicio	C1 Deconstrucción/Demolición	C2 Transporte	C3 Tratamiento de Residuos	C4 Vertido de Residuos	
Potencial de Calentamiento global (GWP) *kg CO_2 equiv/UF*	1,89E+00	8,40E-02	9,80E-02	0	0	0	0	0	0	0	Irrelevante	1,82E-02	0	5,33E-03	MND[2]
	Contribución total de calentamiento global resultante de la emisión de una unidad de gas a la atmósfera con respecto a una unidad de gas de referencia, que es el dióxido de carbono, al que se le asigna un valor de 1.														
Agotamiento de la Capa de Ozono (ODP) *kg CFC 11 equiv/UF*	1,68E-07	5,74E-08	1,12E-08	0	0	0	0	0	0	0	Irrelevante	1,26E-08	0	1,60E-09	MND
	Destrucción de la capa de ozono estratosférico que protege a la tierra de los rayos ultravioletas (perjudiciales para la vida). Este proceso de destrucción del ozono se debe a la ruptura de ciertos compuestos que contienen cloro y bromo (clorofluorocarbonos o halones) cuando éstos llegan a la estratosfera, causando la ruptura catalítica de las moléculas de ozono.														
Potencial de Acidificación del suelo y de los Recursos del agua (AP) *kg SO_2 equiv/UF*	2,31E-02	4,90E-04	1,19E-03	0	0	0	0	0	0	0	Irrelevante	1,12E-04	0	3,16E-05	MND
	La lluvia ácida tiene impactos negativos en los ecosistemas naturales y el medio ambiente. Las principales fuentes de emisiones de sustancias acidificantes son la agricultura y combustión de combustibles fósiles utilizados para la producción de electricidad, la calefacción y el transporte.														
Potencial de Eutrofización (EP) *kg $(PO_4)^{3-}$ equiv/UF*	2,73E-03	1,33E-04	6,93E-05	0	0	0	0	0	0	0	Irrelevante	2,73E-05	0	7,75E-06	MND
	Efectos biológicos adversos derivados del excesivo enriquecimiento con nutrientes de las aguas y las superficies continentales														
Potencial de Formación de Ozono Troposférico (POPC) *Kg etano equiv/UF*	1,19E-03	1,12E-05	5,88E-05	0	0	0	0	0	0	0	Irrelevante	2,45E-06	0	1,16E-06	MND
	Reacciones químicas ocasionadas por la energía de la luz del sol. La reacción de óxidos de nitrógeno con hidrocarburos en presencia de luz solar para formar ozono es un ejemplo de reacción fotoquímica.														
Potencial de agotamiento de Recursos Abióticos para Recursos No Fósiles (ADP-elementos) *kg Sb equiv/UF*	2,66E-07	1,19E-11	1,33E-08	0	0	0	0	0	0	0	Irrelevante	2,66E-12	0	0	MND
Potencial de agotamiento de Recursos Abióticos para Recursos Fósiles (ADP-combustibles fósiles) *MJ/UF*	2,94E+01	9,80E-01	1,54E+00	0	0	0	0	0	0	0	Irrelevante	2,24E-01	0	4,91E-05	MND
	Consumo de recursos no renovables con la consiguiente reducción de disponibilidad para las generaciones futuras.														

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COLLECTION OF ENVIRONMENTAL INFORMATION

OTROS FLUJOS DE SALIDA															
Parámetros	Etapa de Product	Etapa de Proceso de Construcción		Etapa de Uso							Etapa de Fin de Vida				D Potencial de Reutilización, Recuperación y Reciclaje
	A1 / A2 / A3	A4 Transporte	A5 Instalación	B1 Uso	B2 Mantenimiento	B3 Reparación	B4 Sustitución	B5 Rehabilitación	B6 Uso de energía en Servicio	B7 Uso de Agua en Servicio	C1 Deconstrucción/Demolición	C2 Transporte	C3 Tratamiento de Residuos	C4 Vertido de Residuos	
Componentes para su reutilización *kg/FU*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MND
Materiales para el reciclaje *kg/FU*	1,47E-03	4,06E-07	2,17E-02	0	0	0	0	0	0	0	Irrelevante	9,10E-08	0	0	MND
Materiales para valorización energética (recuperación de energía) *kg/FU*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	MND
Energía Exportada (eléctrica, térmica, ...) *MJ/FU*	0	0	0	0	0	0	0	0	0	0	Irrelevante	0	0	0	MND

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CATEGORÍAS DE RESIDUOS															
Parámetros	Etapa de Producto	Etapa de Proceso de Construcción		Etapa de Uso							Etapa de Fin de Vida				D Potencial de Reutilización, Recuperación y Reciclaje
	A1 / A2 / A3	A4 Transporte	A5 Instalación	B1 Uso	B2 Mantenimiento	B3 Reparación	B4 Sustitución	B5 Rehabilitación	B6 Uso de energía en Servicio	B7 Uso de Agua en Servicio	C1 Deconstrucción/Demolición	C2 Transporte	C3 Tratamiento de Residuos	C4 Vertido de Residuos	
Residuos peligrosos vertidos *kg/FU*	6,65E-03	2,31E-05	3,36E-04	0	0	0	0	0	0	0	Irrelevante	5,18E-06	0	0	MND
Residuos no peligrosos vertidos *kg/FU*	4,69E-01	8,40E-05	9,80E-02	0	0	0	0	0	0	0	Irrelevante	1,96E-05	0	7,70E-01	MND
Residuos radiactivos vertidos *kg/FU*	1,26E-04	1,61E-05	7,00E-06	0	0	0	0	0	0	0	Irrelevante	3,57E-06	0	0	MND

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COLLECTION OF ENVIRONMENTAL INFORMATION

The EPDs can become the main source of information for the eco-efficient application model proposed here, however, since they are not yet sufficiently established to be able to define, from an environmental impact point of view, all the materials that may be present in an execution work -whether urban planning or building works-.

In this respect, EN 15978 itself recognises this situation and, therefore, in the absence of EPD or when these are not completely defined, the use of other sources is recommended, provided that these are duly justified and the worst case scenario is the one with two or more data on similar products.

It is worth highlighting how the aforementioned UNE gives importance to the location of production when establishing the environmental impact of a product, where, obviously, the manufacturing processes and the particularities of each manufacturer can cause this impact to vary significantly.

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COLLECTION OF ENVIRONMENTAL INFORMATION

More specifically, in section '10.3 Data quality' of EN 15978, it specifies the following:

- *"If the environmental data used are in accordance with the requirements of EN 15804, they are assumed to meet the data quality requirements of this standard. If the environmental data are from other sources for which it has not been established whether they are in accordance with EN 15804, the following minimum data quality requirements apply", from which the following of relevance to this thesis stand out:*
- *"the data should be as current as possible. The validation of the data should not be older than 10 years.*
- *"data sets for calculations should be based on average annual data, if applicable; reasons for the use of different assessment periods should be listed."*
- *(...) "the plausibility of the data and the compliance with the rules of EN 15804 must be checked;"*
- *"the field of technological validity must be representative of the region where the production is located".*

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COLLECTION OF ENVIRONMENTAL INFORMATION

On the other hand, in the case of Cype, it has calculations of CO2 emissions and other indicators up to phase A5, as well as other phases - rehabilitation and maintenance based on statistical data of different architectural elements - depending on the version of the software.

Some data obtained from the software is shown below, explaining the origin of the impacts of each material, and this being added to the rest of the impacts of other products that make up a unit of work:

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COLLECTION OF ENVIRONMENTAL INFORMATION

Stages	Phases	GWP (Global Warming Potential) ($kgCO_2eq$)	Recycled material (kg/kg)	Recyclability %
Product	A1/A2/A3	1,89e+0		
Execution	A4 Transport	8,40e-2		
	A5 Construction	9,8e-2		
Use	B5 Rehabilitation	0,00	0	0
End on life	C1 Deconstruction	0,00	0	0
	C2 Transport	1,82e-2		

Example of stages included in the calculation methodology per m^2 of product. Based on ECO Platform EPD.

THERMAL INSULATION

PRODUCT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

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CEMENTITIOUS ADHESIVE

PRODUCT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

M2 OF INSULATION IN PLACE

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

Theoretical example of calculation of the environmental impact of thermal insulation installed per m^2.

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COLLECTION OF ENVIRONMENTAL INFORMATION

MONOCAPE

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

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BRICK

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

+

PERFORATED BRICK

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

+

PLASTER GARNISH

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

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RENDERING

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

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PAINTING

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

+

THERMAL INSULATION

CONSTRUCTION ELEMENT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

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M2 OF FACADE

WORK UNIT

Etapas	Fases	GWP ($kgCO_2eq$)	Material reciclado (kg)	Reciclabilidad %
Producto	A1/A2/A3	1,89e+0		
Ejecución	A4 Transporte	8,40e-2		
	A5 Construcción	9,8e-2		
Uso	B5 Rehabilitación	0,00	0	0
Fin de Vida	C1 Deconstrucción	0,00	0	0
	C2 Transporte	1,82e-2		

Theoretical example of the calculation of the environmental impact for each WK (Unit of Work). Example of façade.

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COLLECTION OF ENVIRONMENTAL INFORMATION

H Phase A4 FachT m2 Complete works unit.

Enclosure to the façade hood formed by masonry of 1/2 foot thick or triple hollow brick of 24x11, 5x11. 5 cm laid with cement mortar CEM II/ AP 32, S R, and dosage 1:6 (M-40), internally rendered with cement mortar and 1:4, and externally with monolayer for waterproofing and decoration of facades, finished with projected aggregate, yellow colour, thickness 15 mm, applied manually, reinforced and reinforced with anti-alkali mesh in the changes of material and in the forging fronts. Insulation formed by compact mineral wool panel, high density sand "ISOVER" according to UNE-EN 13162, 60mm thick, uncoated, thermal resistance 1.55 m2K/W, thermal conductivity 0.035W/(mK). Inner leaf of façade enclosure, 7 cm thick, of double hollow ceramic brick masonry, for cladding, 24x11, 5x7cm, received with cement mortar made on site, with 250 kg/m3 of cement, grey colour, dosage 1:6, supplied in sacks.

WU BIM web link	Decomp/ Keynote	U	Complete work unit
proposed url	HFaseA4FachTesis	m2	Enclosure to the façade hood formed by 1/2 foot thick masonry of triple hollow brick 24x11.5x11.5 cm, sphosed on the inside with cement mortar and on the outside with monolayer for imperviousness. Insulation formed by compact mineral wool panel. High-density sand. Inner leaf of 7 cm thick façade enclosure, made of double hollow ceramic brickwork, to be clad 24x11.5x7 cm.

EWL code	Waste generated	Weight (kg)
17 01 02	Bricks	17,9
01 04 08	Waste gravel and crushed rocks other than those mentioned in 01 04 07	0,325
17 01 01	17 01 01 concrete	1,774
17 06 04	Insulation materials other than those mentioned in 17 06 01 and 17 06 03	0,121
17 02 03	Plastic	0,253

Consum		Stage of the life cycle	
		Manufacturing	Construction
		A1-A2-A3	A4 Transport
Materials	Weight (kg)	Emissions CO2eq. (kg)	Emissions CO2eq. (kg)
Ceramic material	127,859	43,152	0,420
Aggregates	53	0,281	0,070
Cement	41,821	7,790	0,631
Mineral wool	2,52	3,230	0,143
Plastic	0,025	0,259	0,000
Water	8,000	0,008	0,000
Fibreglass	0,047	0,111	0,001
Material emissions	233,272	54,831	1,265

Packaging

15 01 01	Paper and cardboard packaging	0,067		0,088	0,002
17 02 03	Plastic	0,211		2,186	0
17 02	Wood	1,848		0,161	0,006
Transport to landfill		22,5			
		TOTAL	**233,272**	**57,266**	**1,273**
				64,339	

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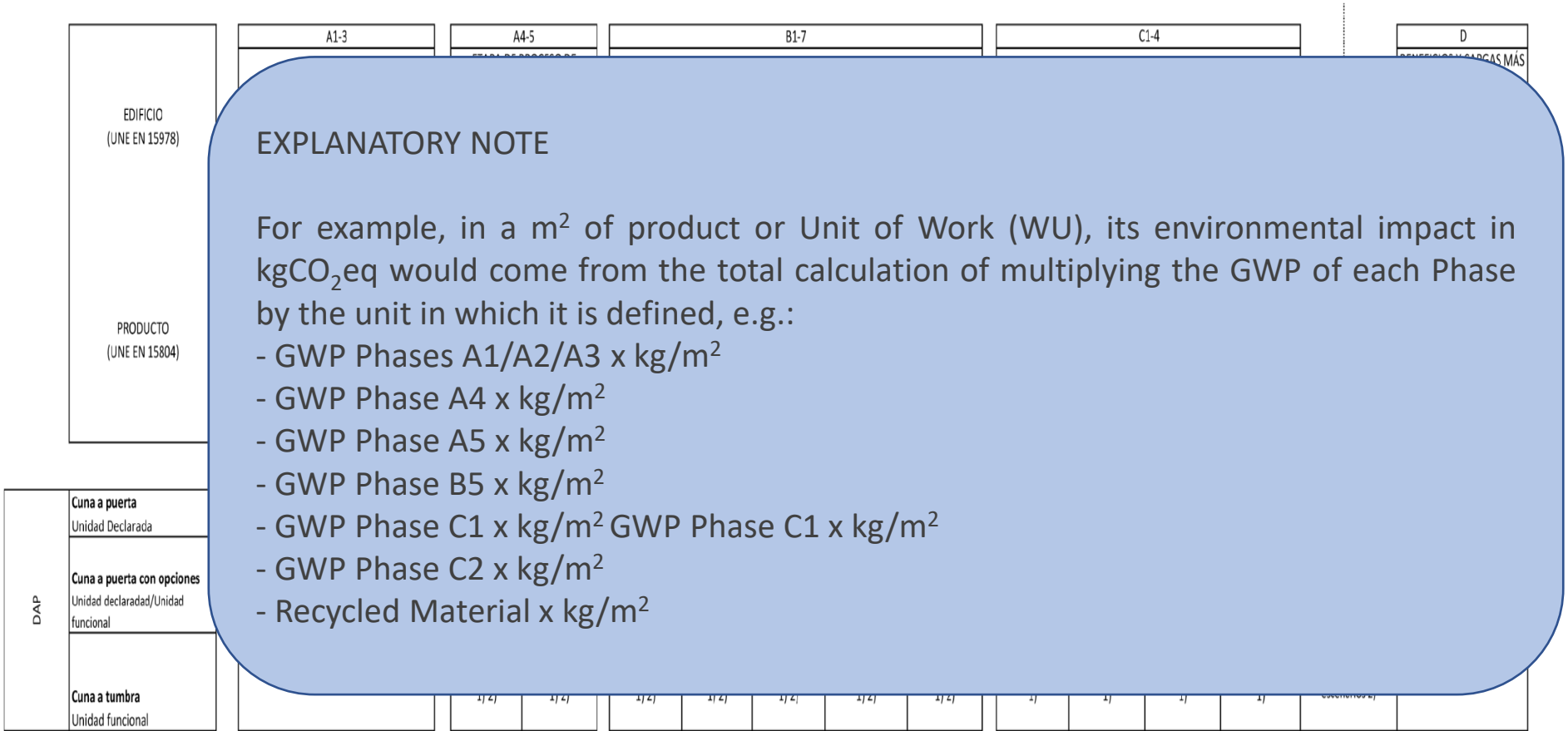
CALCULATION ANALYSIS OF EACH STAGE

According to the calculation methodology of UNE-EN 15978:2012, the sum of each and every one of these impacts by their quantities on site will give the total impact of the building.



EXPLANATORY NOTE

For example, in a m^2 of product or Unit of Work (WU), its environmental impact in $kgCO_2eq$ would come from the total calculation of multiplying the GWP of each Phase by the unit in which it is defined, e.g.:

- GWP Phases A1/A2/A3 x kg/m^2
- GWP Phase A4 x kg/m^2
- GWP Phase A5 x kg/m^2
- GWP Phase B5 x kg/m^2
- GWP Phase C1 x kg/m^2 GWP Phase C1 x kg/m^2
- GWP Phase C2 x kg/m^2
- Recycled Material x kg/m^2

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CALCULATION ANALYSIS OF EACH STAGE

It is therefore possible to intuit how this methodology should be applied to link the BIM model with the calculation of the environmental impact based on the aforementioned EN 15978 and the methodology explained above, specifically for the stages available and obtaining data not contained in the EPDs in other ways.

The following table shows an outline of the application of the LCA methodology according to EN 15978 through the BIM model.

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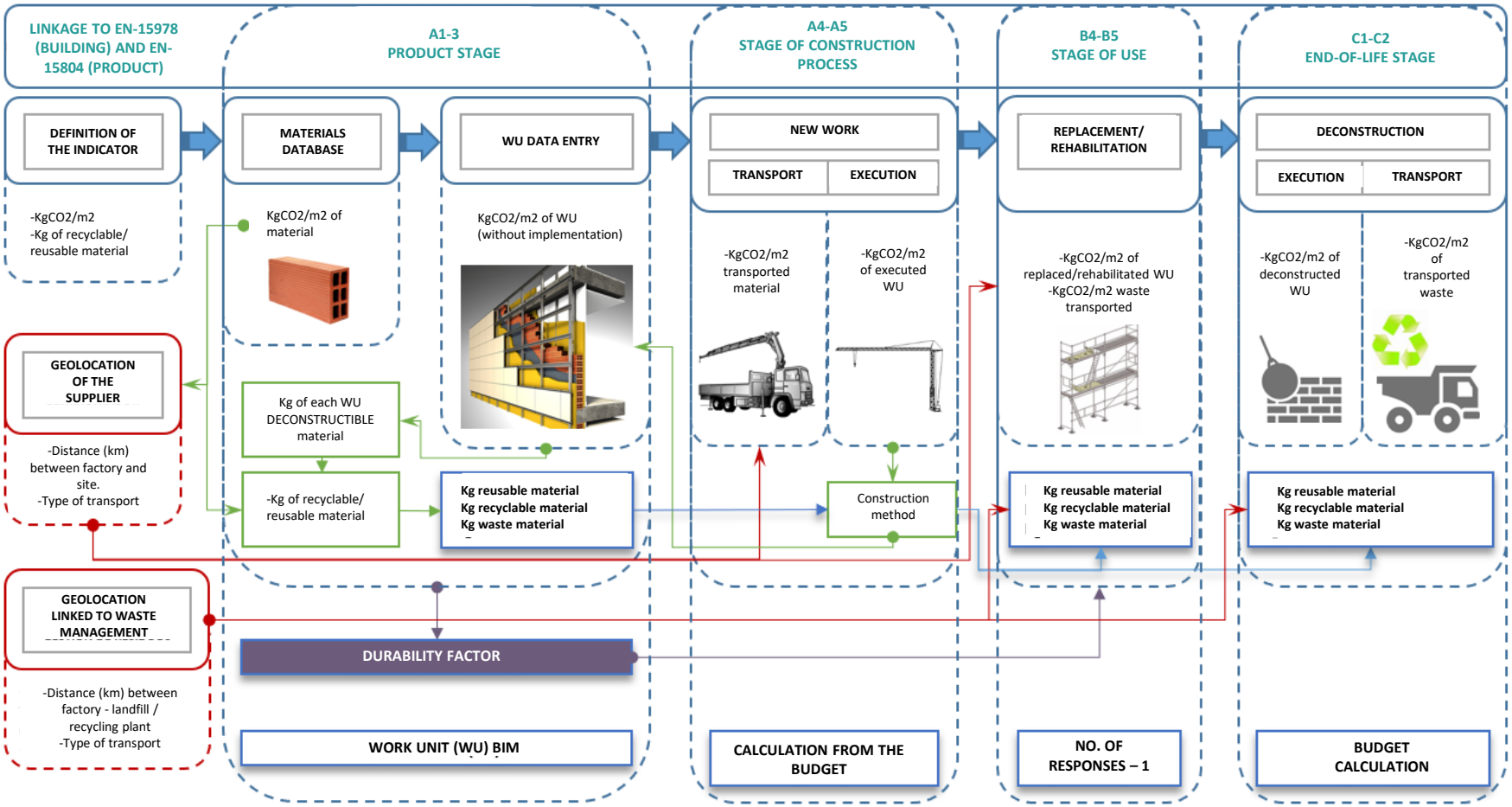
CALCULATION ANALYSIS OF EACH STAGE



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CALCULATION ANALYSIS OF EACH STAGE

PRODUCT STAGE (A1-A3)

The EPDs are very important sources of information, since for those products that have an EPD, a life cycle analysis of at least this stage is mandatory, and there is currently a lot of information on the market on these 3 phases (A1-A3).

However, in the absence of such data for a given product, other databases, LCA software and previous research should be used.

The possibility of geolocating the supply points of the materials in a BIM object LOD600 or in a calculation software should also be emphasised.

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CALCULATION ANALYSIS OF EACH STAGE

NEW CONSTRUCTION STAGE (A4-A5)

In addition to the geolocation of the products through the suppliers - which is important for a more accurate calculation of phase A4 -, the use of machinery and auxiliary elements during the execution (phase A5) must also be taken into account.

Consequently, at this stage the correct definition of the BIM WU (BIM Unit of Works, i.e. a BIM object with information of the execution process, LOD400) will be crucial for its interoperability with a budget calculation software, including not only these two phases, but also the rest.

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CALCULATION ANALYSIS OF EACH STAGE

USE AND REHABILITATION PHASE (B1-B7)

This phase focuses on the calculation of maintenance and rehabilitation works required due to the difference in durability of the materials with respect to the useful life of the building, since in several cases the durability of the materials may be less than that of the building, thus proposing a possible rehabilitation or replacement of these construction elements taken into account from this first phase of building design or focused on buildings already constructed. This information could be contained in a BIM object with LOD500.

Consequently, it is logical to think that the durability of a product will be the main influencing factor for the number of refurbishments of a WU or part of it.

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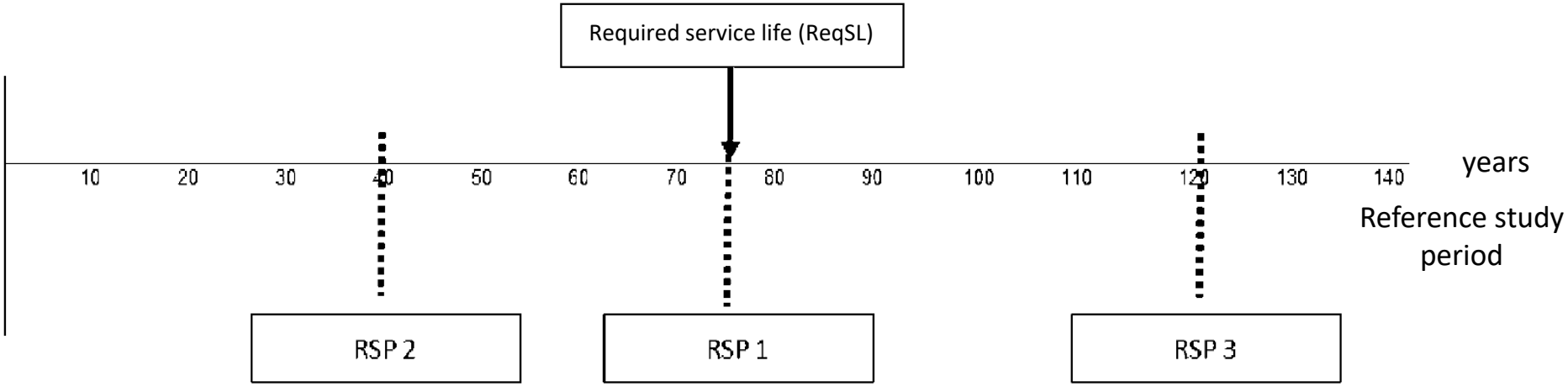
CALCULATION ANALYSIS OF EACH STAGE

USE AND REFURBISHMENT STAGE (B1-B7): DURABILITY OF MATERIALS OR BUILDING UNITS

Therefore, assuming a useful life of the building of e.g. 75 years (as in the picture shown), for those materials or building units with a shorter useful life, the number of times required for their replacement would be interpolated.



Reference Study Period (RSP) versus Required Service Life (ReqSL) of the object of assessment according to EN 15978.

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CALCULATION ANALYSIS OF EACH STAGE

USE AND REFURBISHMENT STAGE (B1-B7): DURABILITY OF MATERIALS OR BUILDING UNITS

This method is described in EN 15978 by the following formula:

$$"NR\ (j) = E\ [ReqSL/ESL(j) - 1]$$

where:

- E [ReqSL/ESL(j) - 1] is a function that rounds ReqSL/ESL(j) to the upper integer value;
- ESL(j) is the estimated useful life of product j;
- NR(j) is the number of substitutions of product j;
- ReqSL is the required service life of the building".

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CALCULATION ANALYSIS OF EACH STAGE

DECONSTRUCTION STAGE (C1-C4)

This phase corresponds to the demolition, deconstruction or dismantling (as an ideal execution process) of the building, due to the extra effort that is desired to be applied on those materials that have the possibility of at least a second life entering again in the value chain, either again as construction material or with another use through a reuse or recycling process, thus promoting the circular economy.

For the development of BIM objects or software, the C2 phase of transport will also be taken into account in a similar way to A4 for each type of material, where it is clear that these do not stand out for their timelessness, however, they can be part of the calculation as an estimate:

- Geolocation of landfills and recycling plants.

- Method/Characteristics of transport.

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CALCULATION ANALYSIS OF EACH STAGE

RECYCLING OR LANDFILL STAGE (D)

This information shall be shown in kg of waste or recycled. If shown as a percentage (%) recyclability it would be calculated from the ratio of kgs of recyclable material to kgs of material used.

This ratio is also possible with a percentage (%) reusability to kgs of material used. The big difference lies in the energy consumption and environmental impact of subjecting a material to a recycling process as opposed to being reused directly. In this approach, the selected construction methods are crucial for a building approach with the highest possible % reusability.

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CALCULATION ANALYSIS OF EACH STAGE

RECYCLING OR LANDFILL STAGE (D)

That is, if this analysis were extrapolated to a WU (Unit of Works), one could observe how the recyclability or reusability would vary downwards as it enters into conjunction with other materials in the necessary construction processes.

For example, natural stone laid without adhesives could be reused at the end of a building's life. It is worth mentioning that prefabrication and the study of new, more sustainable construction systems, as well as their study for their applicability in BIM, will be necessary to increase this rate of recyclability and/or reusability in the deconstruction of buildings constructed under this criterion.

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DATA INTEGRATION IN BIM OBJECTS

Consequently, in calculation methodology models with software based on environmental information contained in BIM objects would require LOS600 development, as well as the parameterisation of these BIM objects and their development at LOD400 and LOD500 levels.

Current calculation software based on databases and not on information contained in BIM objects, usually do not allow as much specificity as could be achieved from the customisation of a BIM object, which belongs to a specific manufacturer.

An example of data integration in a BIM object is shown below.

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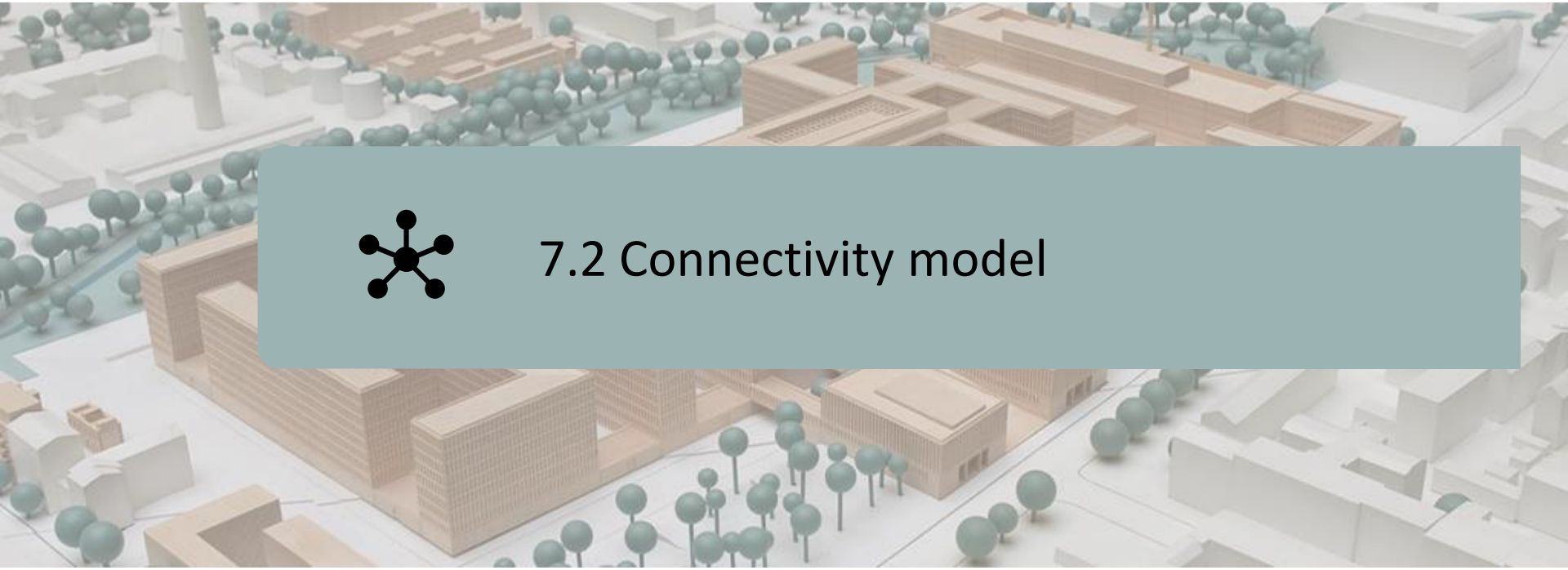

7.2 Connectivity model

LOD700

BIM & GIS

CONNECTIVITY MODEL

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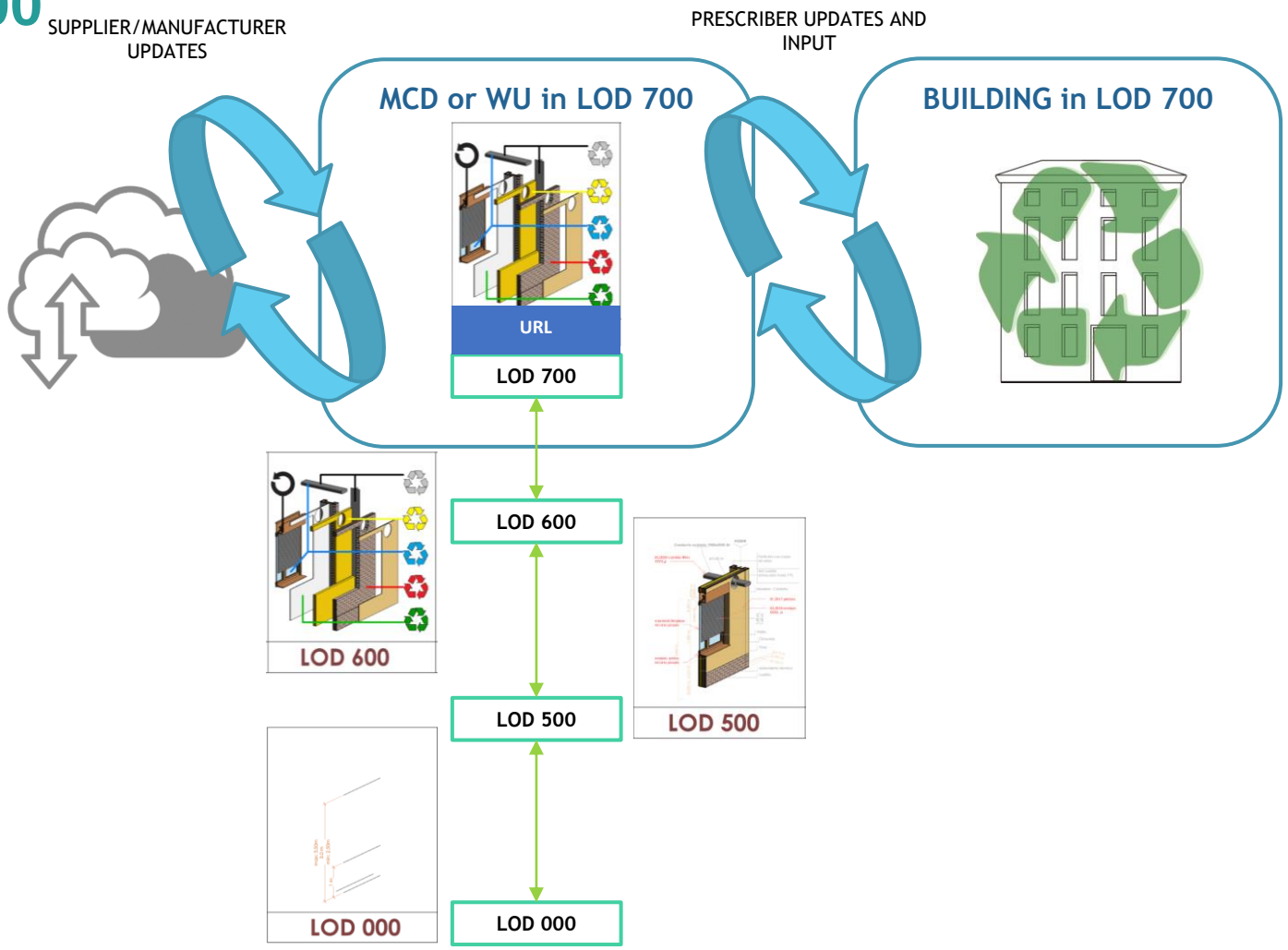
LOD700

This LOD (Caparrós-Pérez, 2017) defines the degree of connectivity, where the updating of the BIM elements in the cloud would be automatically carried out in the architectural BIM model; specifically, technical specifications, budgets, environmental impact indicators, etc.

For example, when the elements are in the cloud, and some of their characteristics are updated, these would be automatically implemented by prior permission of the users who are drawing a BIM building model connected to the cloud.

LOD700



Connectivity of the LOD 700

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LOD700

Cloud connectivity through WU BIM (Unit of Work in BIM object) at LOD700 development level allows a different business model for manufacturing and supplying companies, which will be forced to develop this advance on their own, where technology and environment share the same path, i.e. the digitalisation of their products and the accuracy of the information in relation to their environmental impact.

Consequently, one of the novelties in this methodology lies in the active participation of the manufacturing companies, as it is proposed to link them through the following actions:

Geolocation of product supply points.

Inclusion of data related to the EPD of their products (from all available stages).

Online linking of products not only to their budgetary but also to their environmental characteristics.

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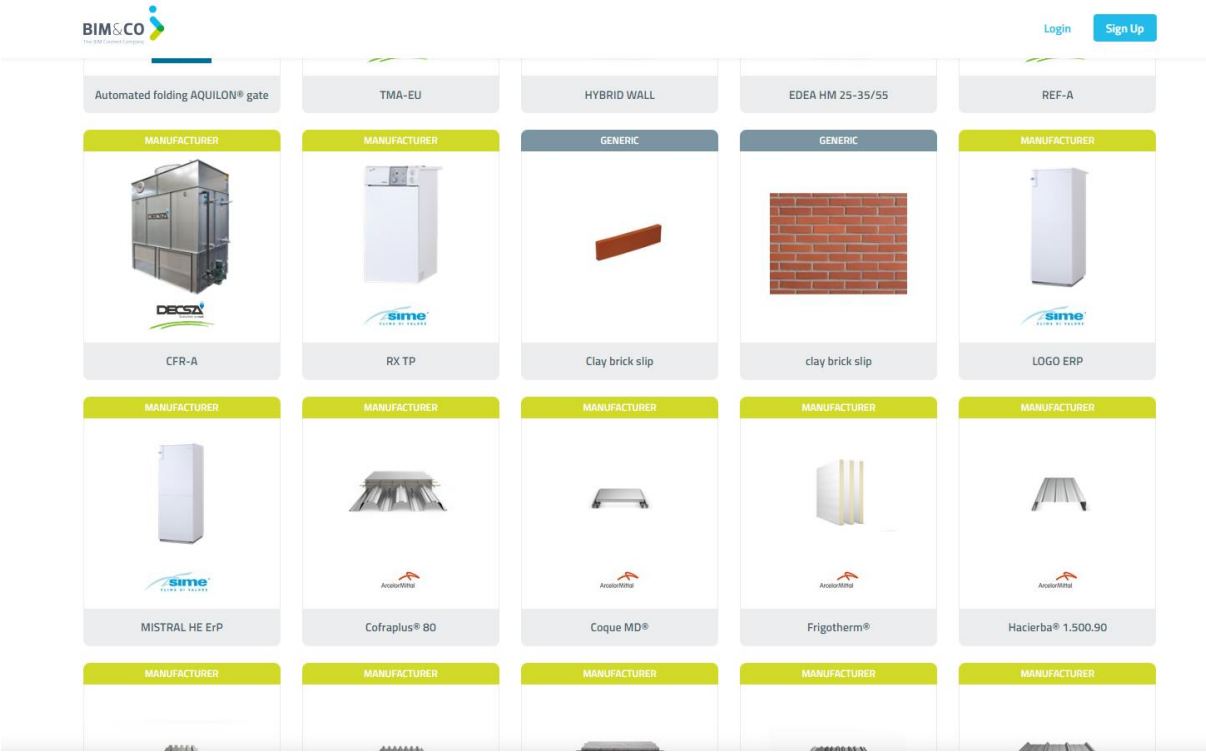
LOD700

Therefore, in the future it will be necessary to develop collaborative platforms and architectural design software with BIM objects in LOD700 for full connectivity of suppliers and manufacturers to specifiers with embedded LCA information.

Example of a collaborative BIM object exchange platform with LOD layers



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BIM & GIS

GIS

For the modelling, transport and storage of geographic information there are the GML formats, which are a sub-language of XML.

It was produced by the OpenGIS group - now OCG - and developed through the ISO 19100 series of standards.

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BIM & GIS

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EXPLANATORY NOTE

CONCEPTS:
- GIS or GIS: Geographic Information Systems / Sistemas de Información Geográfica.
- GML: XML with geographic content. From the acronym for Geography Markup Language.
- XML: Meta-language used to store data in a readable form.
- ISO 19100 standards for the production and management of geoinformation.

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BIM & GIS

GIS

It should be remembered that Directive 2007/2/CE -commonly known as INSPIRE-, which has been transposed into Spanish legislation in Law 14/2010 -commonly known as LISIGE-, establishes two types of formats:

- CP (Cadastral Parcel) for cadastral parcels, complying with the standard defined in "INSPIRE Data Specification on Cadastral Parcels".

- BU (Building) for buildings. The official program for validation of the GML of parcels can be found in the electronic site of the Cadastre *(more information: https://www.geograma.com/2018/03/09/el-formato-gml-en-el-registro-de-la-propiedad/).*

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BIM & GIS

GIS

GML formats are currently very widespread, in fact, in the seventh requirement of the Resolution of 29 October 2015, of the Undersecretariat, on the "requirements to be met by the technical description and the alternative graphic representation of the properties provided to the Land Registry", section "b" states the following:

"b) It must be contained in the computer file, in GML format (...), whose data must correspond to the descriptive and surface area data of the resulting plot or plots whose registration is requested. The aforementioned file must be electronically signed, where applicable, by the technician who has been involved in its preparation, and authenticated by electronic signature or by other reliable means by the owner or competent authority, as appropriate".

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BIM & GIS

GIS

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EXPLANATORY NOTE

RESOLUTION of 29 October 2015, of the Undersecretariat, publishing the joint Resolution of the General Directorate of Registries and Notaries and the General Directorate of Cadastre, regulating the technical requirements for the exchange of information between the Cadastre and the Land Registries. https://www.boe.es/diario_boe/txt.php?id=BOE-A-2015-7046

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BIM & GIS

GIS

This joint resolution aims to respond to the technical requirements arising from the reforms that Law 13/2015 has incorporated into the Mortgage Law and the TR Cadastre Law regarding the exchange of information between the Cadastre and the Land Registries. It also develops how registrars, cadastre officials, private individuals and technicians are to operate with each other.

Due to this law, technicians who have to modify a cartography for its presentation to the competent body must present it in GML format and digitally signed by said technician.

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BIM & GIS

GIS

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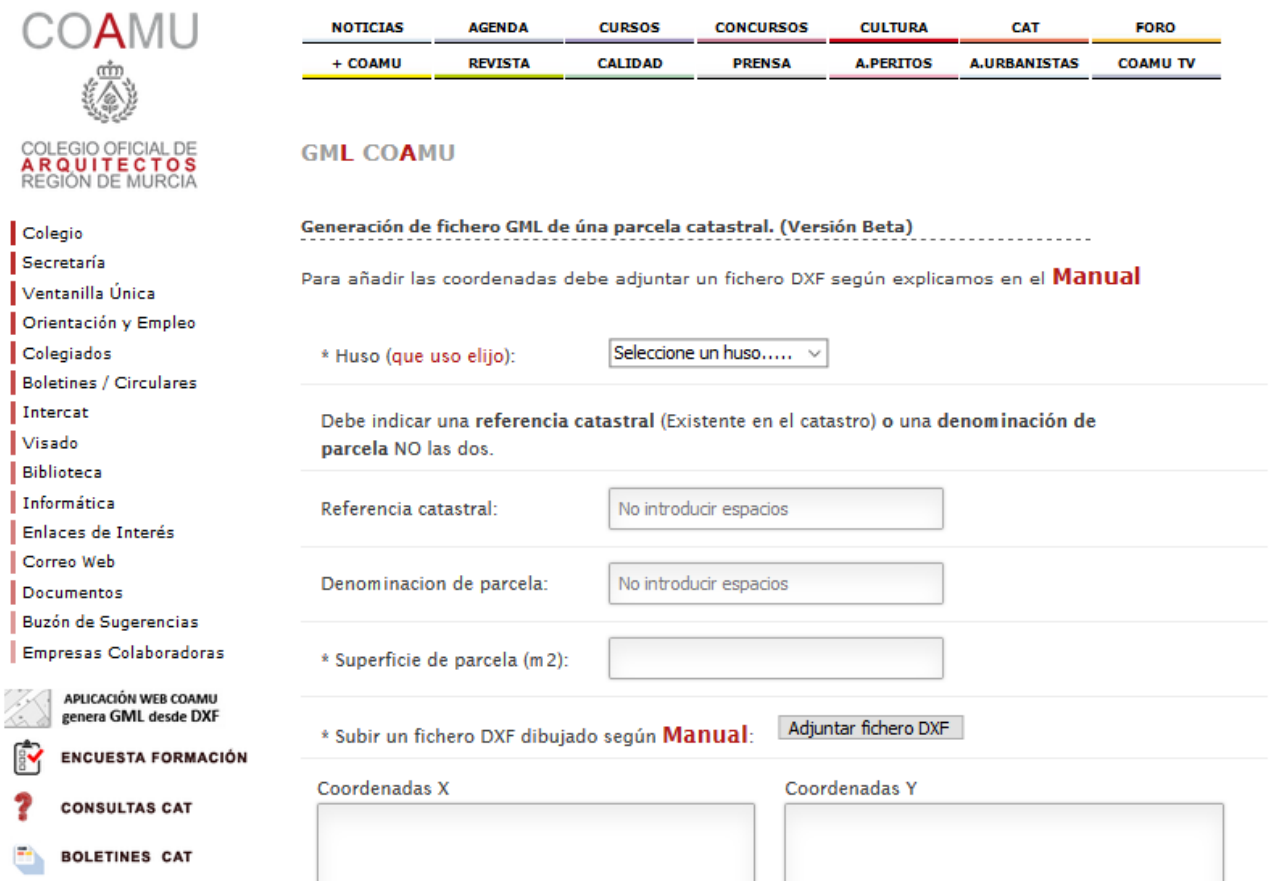
Due to this law, technicians who have to modify a cartography for its presentation to the competent body must present it in GML format and digitally signed by said technician.

EXPLANATORY NOTE

LAW 13/2015, of 24 June, on the Reform of the Mortgage Law approved by Decree of 8 February 1946 and of the revised text of the Law on Real Estate Cadastre, approved by Royal Legislative Decree 1/2004, of 5 March.

BIM & GIS

GIS



Generation of a GML file from DXF formats of a cadastral parcel in an application of the COAMU website (Colegio Oficial de Arquitectos de la Región de Murcia).

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BIM & GIS

INTEROPERABILITY

Interoperability between BIM and GIS has become a priority in recent years, where it can be stated that existing types of GIS formats are capable of supporting the information that could be introduced on environmental impact and other indicators.

Data integration through building information based on geographic information system (GIS) modelling (BIM) has emerged as an important area of research for the extraction of valuable information that can support decision making.

Note that ISO/TC 59/SC 13 collaborated with ISO/TC 211 on the standard "ISO/CD 19166, Geographic information. BIM to GIS conceptual mapping (B2GM)", precisely on the development of interoperability between the two.

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BIM & GIS

INTEROPERABILITY: ISO/CD 19166

In particular, to realise smart urban services, such as facilities including effective building and energy management, we need to consider the information perspective, which can be represented by considering service-related use cases and combining information from the BIM and GIS they want to use, including information about the building and infrastructure objects of a city.

We also need to consider other heterogeneous data models, such as facility management (FM) database systems.

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BIM & GIS

INTEROPERABILITY: ISO/CD 19166

There have been some attempts to compile information in BIM and use it in GIS developments, but there is no established way of mapping the data elements between these two worlds. Proper mapping is clearly necessary. From a GIS point of view, there are many benefits related to the use of BIM in GIS applications. Some examples are:

- Implementation of indoor services, such as emergency management (e.g. directing and finding evacuation routes in a fire situation);
- Indoor/outdoor liaison services, such as seamless navigation; and
- Efficient facility/energy/environment management both at building, urban and territorial level, considering BIM-related objects based on GIS.

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BIM & GIS

INTEROPERABILITY: ISO/CD 19166

However, it is also necessary to state that an unclear BIM-GIS model integration method can cause the following problems, hence the need to have developed this ISO standard:

- Difficulty for the user to predict the results of model integration.
- In the model integration process, information necessary for the execution of the use case can be eliminated.
- Information unnecessary for the execution of the use case may be withheld. Unnecessary information may hinder the management of the integrated model and may increase the management time and cost.
- Wrong information about the integrated noise can lead to bad results in service execution or decision making.

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BIM & GIS

BUILDING, URBAN PLANNING AND TERRITORY

Thus, it is possible to consider the cartographic computer model in combination with BIM formats and environmental impact calculation methodologies, from the steps to be taken from the finalisation phase of the BIM model to its cartographic model:

- BIM model.
- Automatic generation.
- Processes.
- Integration in the cartographic system

BIM & GIS

CREATION OF THE BIM MODEL

BIM MODEL

IFC or similar

CALCULATION RESULTS

BC3

CADASTRE GIS MODEL

GML or similar

BIM IN MAPPING

AUTOMATIC GENERATION

Combination of input data:

- IFC
- BC3 (kg of materials, kg of building elements, % recyclability, kgCO2).
- GML. Link with cadastre

IDENTIFICATION

Cadastral association in 3D

INTEROPERABILITY OF INFORMATION

PROCESSES

Automatic extraction of data on kg of materials, kg of building elements, % of recyclable materials, kgCO2, etc. per building cadastral reference.

IDENTIFICATION

Automatic extraction of data by cadastral reference of dwelling, premises, etc.

BIM+GIS PUBLIC ACCESS

CURRENT SOLUTION

Dumping of information (processed indicators) to servers. GML

FUTURE SOLUTION

Dumping of information (processed indicators) to servers. CityGML

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BIM & GIS

1. BIM model.

The delivery of the project documentation is done in BIM through IFC formats, where the environmental impact indicators are defined in their digital construction materials and work units in BIM. On the other hand, through budget calculation tools, the total environmental impact of the entire project can be calculated. The third component to take into account at this point is the mapping of the project in GML format.

2. Automatic generation.

At this point, it would be necessary to use a computer application for the introduction of these environmental impact data in a compatible GML format, for delivery to the competent bodies. The main reason for the development of this application is due to the lack of knowledge of the technicians in writing in XML code, in addition to facilitating this work rather than complicating it, hence the need to automate this step.

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BIM & GIS

3. Processes.

This information would be available in the cadastral data of each building and, therefore, of each property. It should be borne in mind that this assignment model for each cadastral reference would also be applicable to energy efficiency certificates, as this information would be available in the cadastre.

4. Integration in the cartographic system.

Under the model described here, this information would be available in the cadastre for public consultation, either for compliance with future regulations in relation to the efficiency of material resources or for its application in urban developments or rehabilitations, in GML format in a first implementation process, or in CityGML for future adaptation of the cadastre to this type of formats when they are fully standardised and their interoperability with BIM (IFC, BIMXML or similar) has been developed.

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BIM & GIS

3. Processes.

This information would be available in the cadastral data of each building and, therefore, of each property. It should be borne in mind that this assignment model for each cadastral reference would also be applicable to energy efficiency certificates, as this information would be available in the cadastre.

4. Integrati

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EXPLANATORY NOTE

BIMXML describes building data (sites, buildings, floors, spaces and equipment and their attributes) in a simplified spatial building model (extruded shapes and spaces) for BIM collaboration.

XML Schema was developed as an alternative to full-scale IFC models to simplify data exchanges between the various AIC (Architecture, Engineering and Construction) applications and to connect Building Information Models via Web Services.

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CONNECTIVITY MODEL

Therefore, in the future it will be possible to bring together the two previous concepts of BIM object developments at LOD700 levels with integrated environmental impact data with a GIS-based connectivity model of all this information, as shown in the following scheme.

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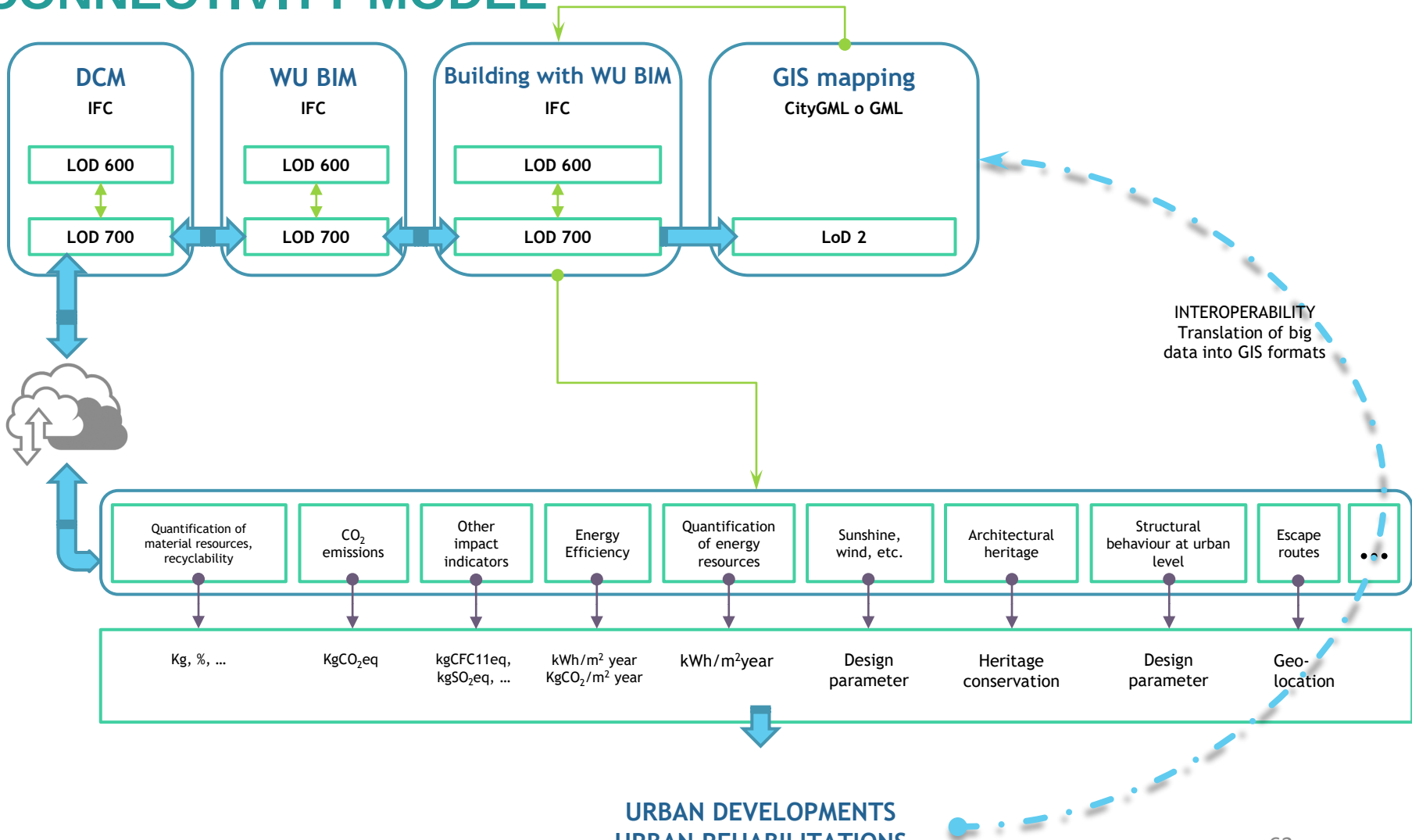
CONNECTIVITY MODEL



*DCM. Digital Construction Material in BIM.
*BIM WU. Unit of Work in BIM object.

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CONNECTIVITY MODEL

In recent years the scientific production around the applicability of BIM and GIS in the development of Big Data has increased exponentially, which "is a term that refers to an amount of data such that it exceeds the capacity of conventional software to be captured, managed and processed in a reasonable amount of time. The volume of massive data is constantly growing".

Based on the large amount of information that BIM technologies are capable of managing, Big Data tools have to be developed to be able to interpret all this information from the construction works and the life cycle of buildings.

Thus, the quickest way to deliver the information through a BIM model and store the information massively for processing and analysis is through cloud computing technologies. In this regard, the question arises to identify the most recent developments in the cloud and which of these are suitable for the theoretical model of this thesis. If they are approached from a collaborative model (Autodesk BIM 360, Google Apps, etc.), they may entail licensing problems and incompatibilities between software.

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CONNECTIVITY MODEL

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EXPLANATORY NOTE

Cloud computing,1 also known as cloud services, cloud computing, cloud computing, cloud computing or simply "the cloud", is a paradigm that enables the delivery of computing services over a network, usually the internet.
Cloud computing is the on-demand availability of computer system resources, especially data storage and computing capacity, without direct active management by the user. The term is generally used to describe data centres available from any location to many users via the internet from any mobile or fixed device.

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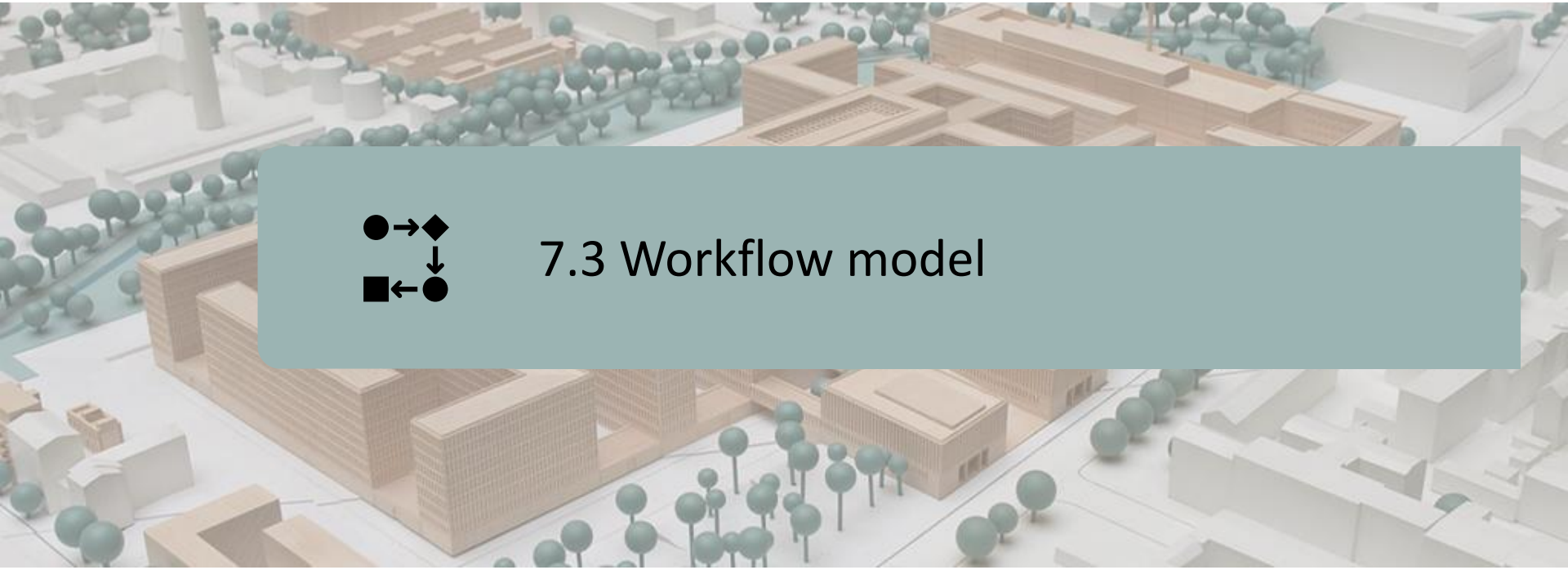

7.3 Workflow model

THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES

IMPLEMENTATION WORKFLOW FOR BUILDING THE DIGITAL CITY

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THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES

In conclusion, all the above mentioned strategies and technologies would have their application in the construction sector at all scales of application as well as throughout the life cycle of the products:

- Material scale
- Building scale.
- City scale.
- Territory scale.

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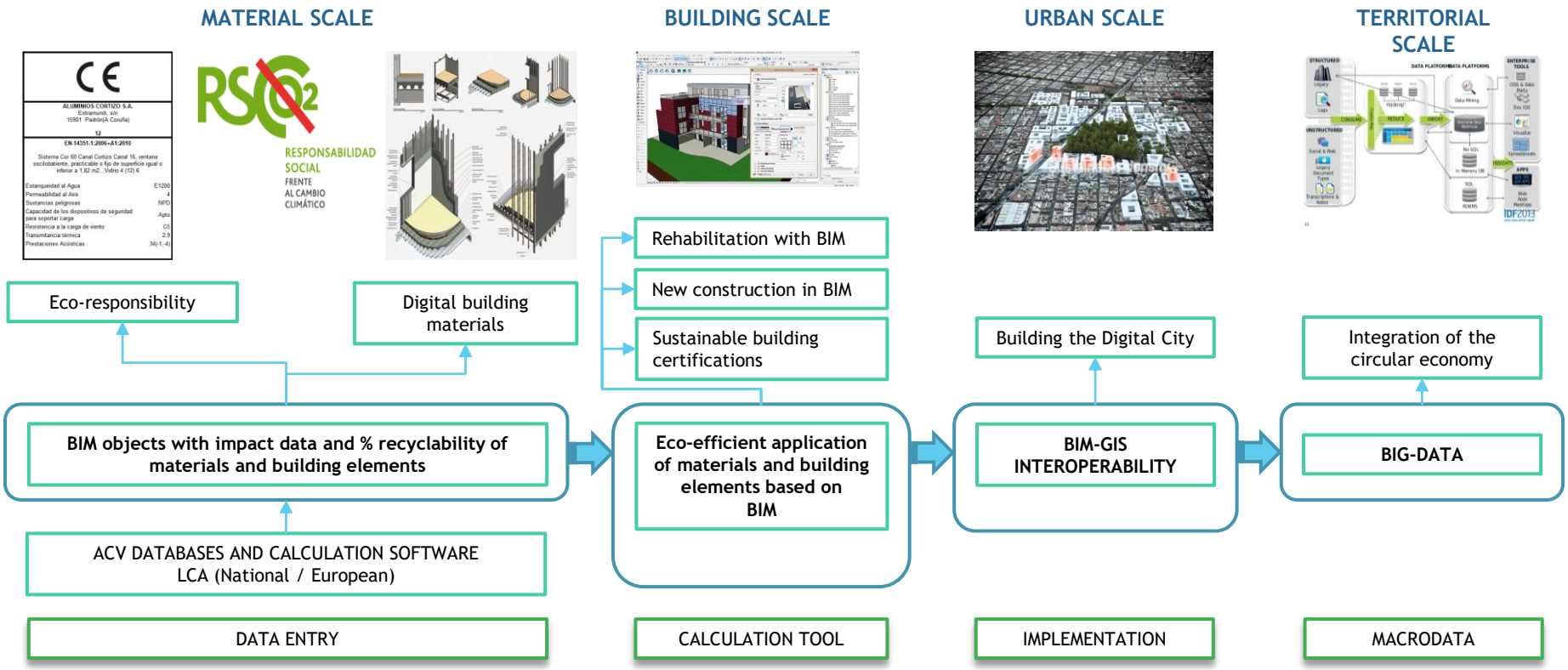
THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES



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THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES

ACTIONS NECESSARY FOR IMPLEMENTATION

MATERIAL SCALE

- It is necessary to develop BIM objects with impact data and % recyclability of materials and construction elements (LOD600) and strategies for updating the information contained in them (LOD700).
- Increased integration of databases in LCA calculation software.
- Increase in the performance of EPDs.
- Normative regulation to make their use compulsory.

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THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES

ACTIONS NECESSARY FOR IMPLEMENTATION

BUILDING SCALE

- Development of software and calculation tools to facilitate the calculation of the LCA of buildings and urban developments for professionals in the construction sector.
- Implementation at the regulatory level for the delivery of BIM documentation and environmental impact information in new buildings and renovations.
- On the part of companies, they would have to definitively adapt to BIM technologies in order to be able to deliver all the necessary documentation in BIM formats, as well as the results of energy efficiency, material consumption, environmental impact, etc. that these would yield.

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THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES

ACTIONS NECESSARY FOR IMPLEMENTATION

CITY SCALE

- Development of mandatory regulations, where the competent bodies would have to legislate the Directives, Royal Decrees, Regulations and Ordinances necessary for the implementation of BIM and material efficiency.
- Through PGMO the appropriate measures can be established, as well as the use of the UNE standards in the specifications of the execution projects and, therefore, obliging their applicability in these.
- Delivery of documentation and access to information to citizens in general, companies and professionals in the sector through cartographies in CityGML or GML, with the information relating to environmental impacts contained in XML.
- Public bodies managing cartography: they would also have to adapt to these new BIM technologies and their interoperability with GIS, from a technological and educational point of view.

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THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES

ACTIONS NECESSARY FOR IMPLEMENTATION

TERRITORIAL SCALE

The information collected would have countless applications, especially those linked to data collection for circular economy strategies at territorial level through Big Data tools where all this information could be reused.

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THEORETICAL WORKFLOW FOR THE IMPLEMENTATION OF ECO-EFFICIENT STRATEGIES

ACTIONS NECESSARY FOR IMPLEMENTATION

TERRITORIAL SCALE

Therefore, it is intended to:

1. Full development of the EPDs and their integration in BIM objects.
2. Connectivity between supply companies and specifiers.
3. Calculation of environmental impacts from BIM.
4. Digitisation and modernisation of the construction sector and public bodies.
5. Gradual construction of the digital city thanks to the regulations adopted in the delivery of project documentation to public bodies.
6. Big Data management of information.

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IMPLEMENTATION WORKFLOW FOR BUILDING THE DIGITAL CITY

As mentioned above, for the building and city scales, it would be necessary for both the private and public sectors to adapt to the implementation of BIM and its combination with GIS.

This flow of information would allow the gradual construction of digital cities, as it would be necessary to deliver execution projects (both new construction and refurbishment) to public bodies for use in electronic tools.

The following graph shows how all the members of the triple helix must ensure the future improvements of the system (research organisations - universities and technology centres - as well as ICT companies), the regulatory bodies must continue with the development of the implementation and the companies and public administrations must become active in the adaptability of this change of paradigm in the construction sector.

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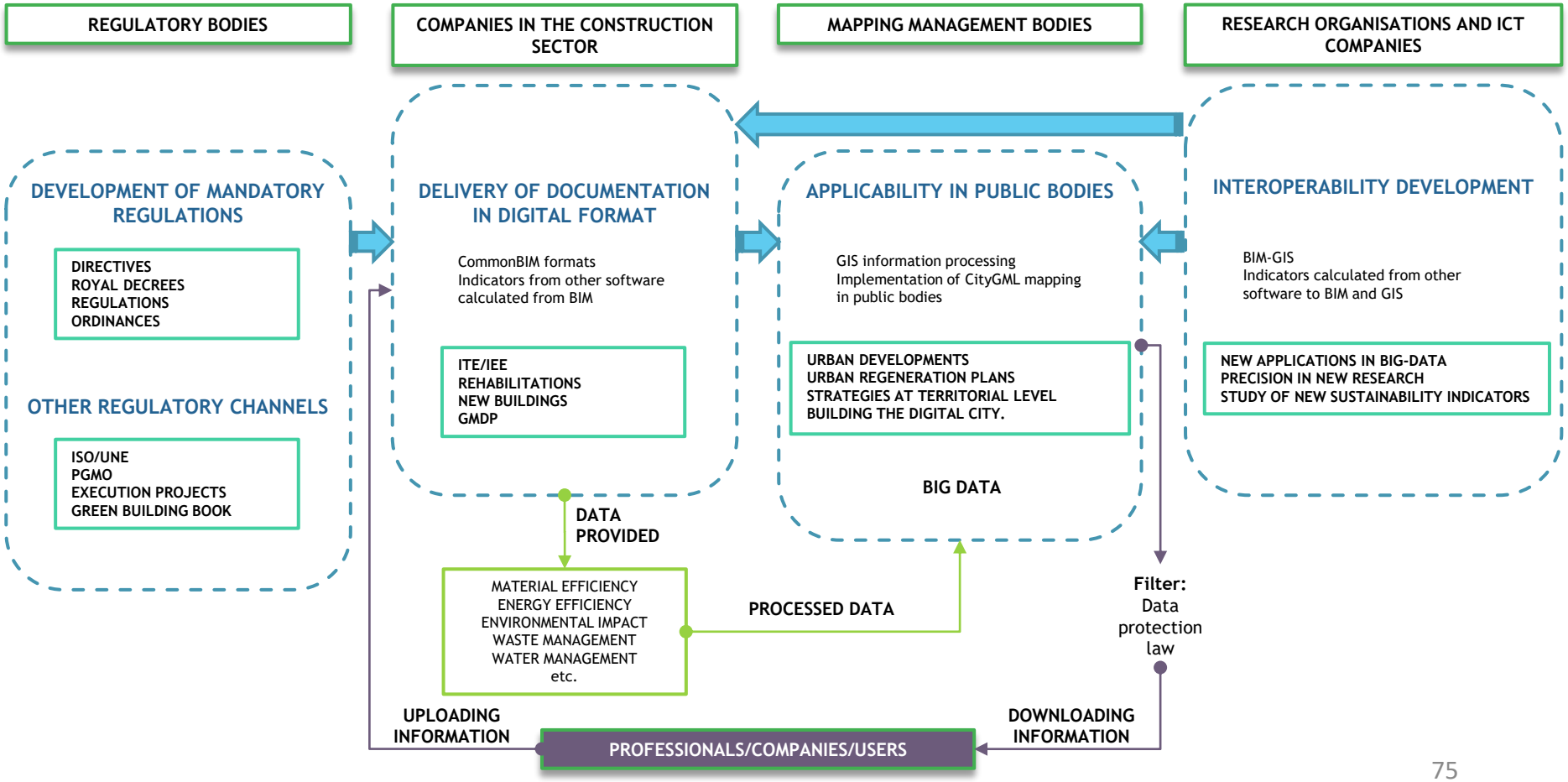
IMPLEMENTATION WORKFLOW FOR BUILDING THE DIGITAL CITY



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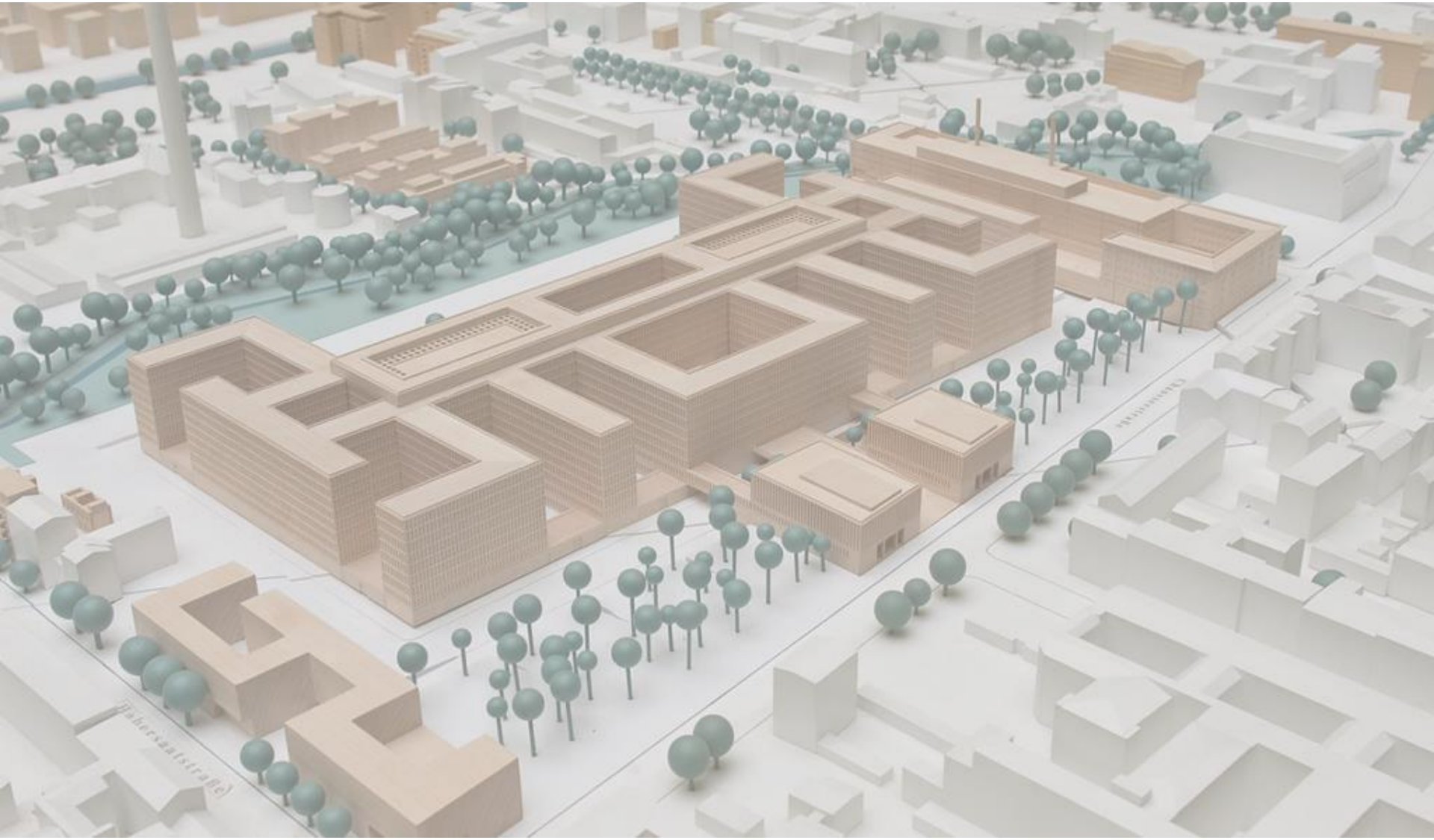

COAMU COLEGIO OFICIAL DE ARQUITECTOS REGIÓN DE MURCIA

iED institute of Entrepreneurship Development

CTM Centro Tecnológico del mármol, piedra y materiales

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