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Evaluation of BIM based LCA in early design phase (low LOD) of buildings

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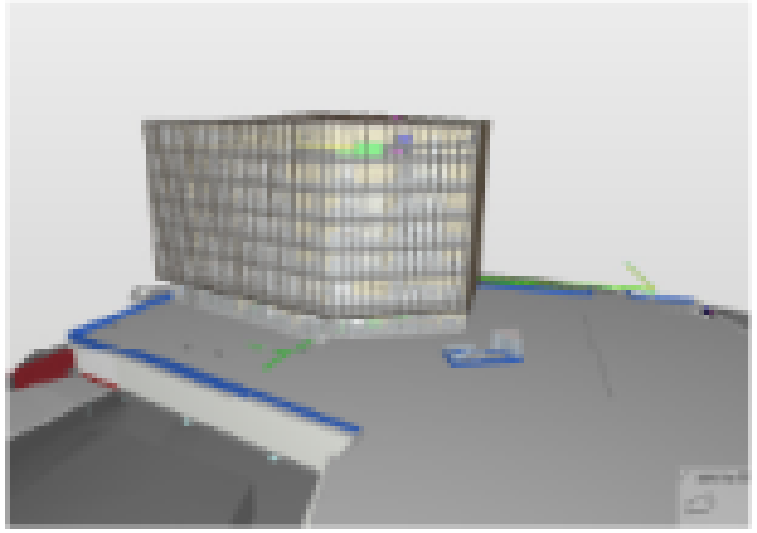
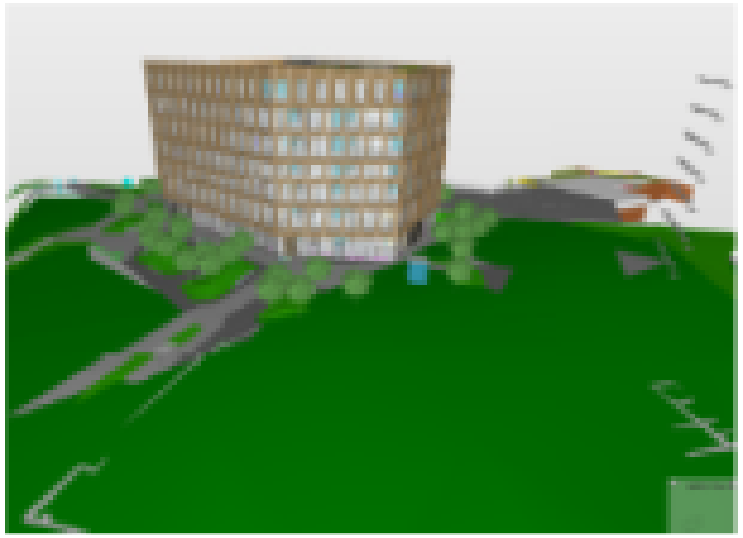
LCA methodology in One Click LCA

LCA methodology and assumptions made in One Click LCA	
Goal and scope definition	Evaluate the Global Warming Potential (GWP) caused by Valle Wood using OCL.
Functional Unit (FU)	FU of this LCA is Kg $CO_2 - eq$ emission per material. The reference unit is m^3. Other units like kg, kW, kWh, l m and m^2 could have been applied, but OCL do not possess a unit conversion factor.
Temporal- and geographical scope	OCL execute a static LCA model. It is possible to setup the service of the materials that would be preferable to include. This will have an impact on B4-B5 (Replacements) during the building life cycle and impacts associated with B6-B7 are introduced on an annual basis. At the moment OCL do not allow changes to the energy mix as this is not allowed in the standards OCL follow. Operating variables do not affect the inventory of the system. Nevertheless - this is out of the scope of the study, and mitigate the potential downsides in terms of only gather Life Cycle Inventory (LCI) data to unit processes, which is the smallest element considered in the LCI for which input and output are quantified [12]. The time period covered in this LCA is updates in the BIM model as per December 2018 [13]. Geographical scope is Oslo, Norway.
Technology coverage	The tool utilized is LCA for BREEAM NOR. The template used to export and structure information from Solibri is "One Click LCA (metric).ITO".
Change-oriented LCA	This is a change-oriented LCA that comparing three BIM models (three LOD levels), up against a modified and reliable LCA at a correct LOD 350.
Intended application	This is a LCA that can be applied to different situations; BIM-model improvement, strategic planning and public decision making.
System boundary	Consider embodied emission, cradle to gate, A1-A3 as this contribute the most to GWP.
LCI analysis and data collection	MS Excel file that imported materials from the BIM (.smc file) and grouped them based on 5 criteria: CLASS: values have to be one of the listed ones in exactly the same format (sorted in .ITO template used in information takeoff in Solibri). IFC-MATERIAL: Use the distinguishable material name to map the material to the label in the tool. Mapping is based on CLASS and IFC-MATERIAL combination. For material label, the database is EPD-Norway. When importing it for the first time, one can teach it to the tool and it will be automatically recognized in the future. QUANTITY: Number, comma as decimal separator. QTY-TYPE: Units. TRANSPORT-KM: Transport distance in km from manufacturer site to the building site (optional, can also be added later in the query).
Data quality	Cut-off criteria to this LCA is materials < 1% of the volume. Also, OCL's category 6, Building Technology, is out of the scope. The cut-off lead to the fallacy of disaggregation by splitting up processes which lower the data quality and putting flows explicitly to zero [14]. The cut-offs are related to undefined objects from the BIM model. Data information included are obtained from EPDs witch follows the same sets of standards.
Life Cycle Impact assessment (LCIA)	The impact category is global warming, characterized as per CML-IA 2012 methodology, required by EN 15978 and EN 15804 [15].
Interpretation	OCL is an transparent analysis as the tool is online and can be easily modified. As this features, this assessment is also a comparative analysis in the way the assessments comparing four alternatives to which performance at different LOD.

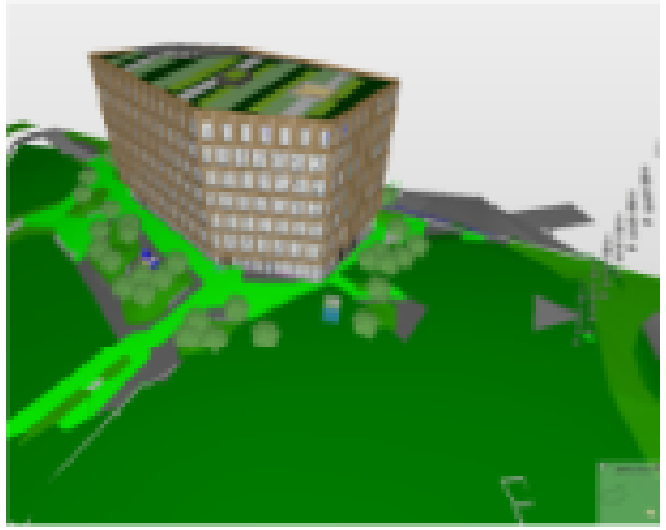
Walle Wood



LOD200



LOD 300



LOD 300

Results from OCL related to different LODs

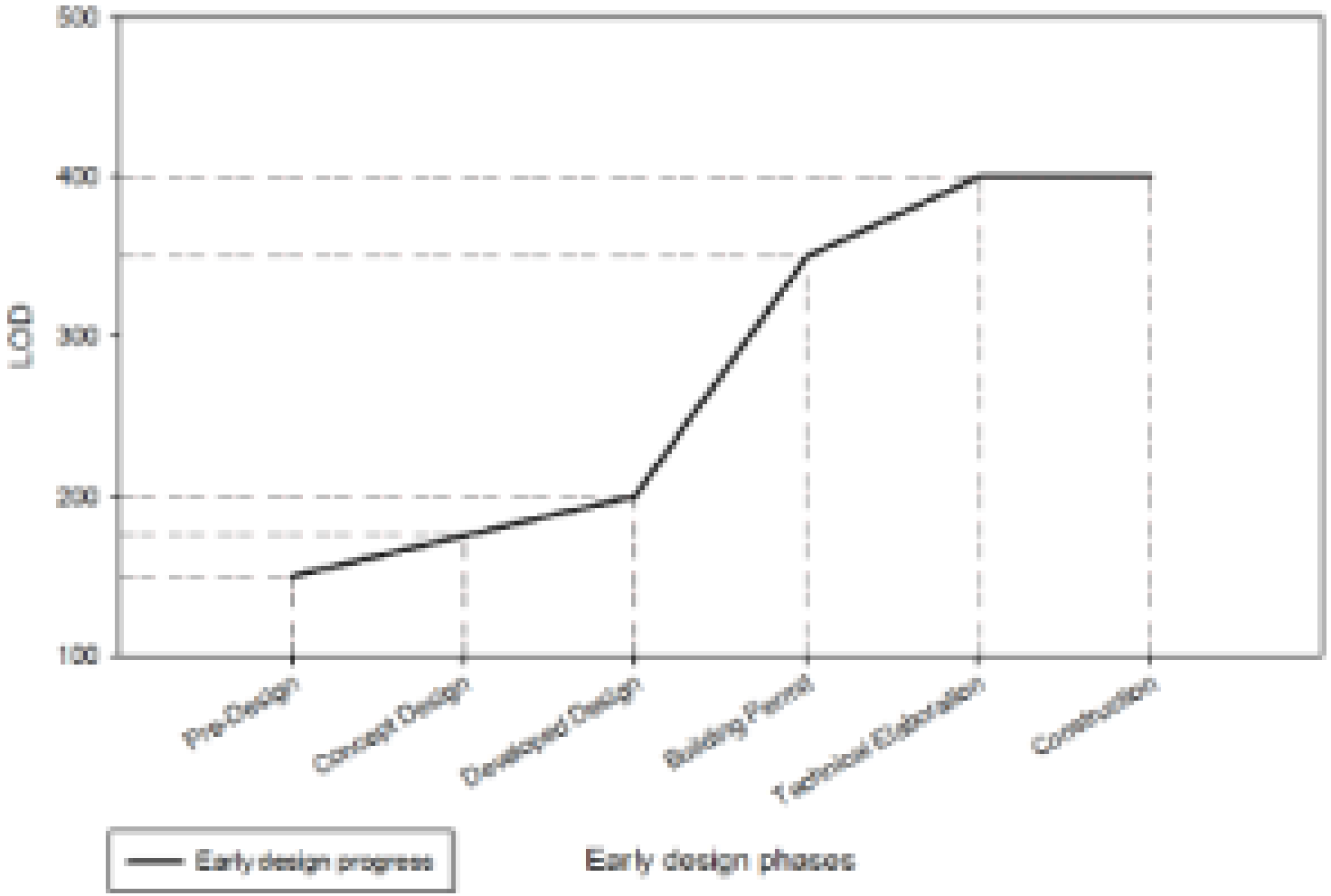
LOD	Builing Element	%	Material Type	%	Material Subtypes	%	Tons of CO_2-eq
LOD 200	Horizontal Structures (HS)	82	Steel and Metals (SM)	88	Aluminum	87	32523
	Other Structures (OS)	12	Concrete	8	Prefab. concrete walls	4	
	Vertical Structures (VS)	6	Glass	2	Concrete foundation	3	
			Timber	1	Cross Laminated Timber (CLT)	1	
			Gypsum	0	Glass	2	
LOD 300	OS	51	SM	74	Aluminum	67	9553
	HS	25	Concrete	21	Prefab. concrete	13	
	VS	24	Floor (undefined)	2	Concrete	5	
	Ground and Foundation (GF)	0	Glass	1	Steel	4	
			Insulation	1	Steel and Iron	3	
LOD 350	OS	56	SM	75	Aluminum	67	8066
	HS	27	Concrete	19	Prefab. Concrete	13	
	VS	17	Timber	3	CLT	12	
	GF	0	Floor (undefined)	2	Steel	5	
			Insulation	1	Concrete	3	
LOD 350 (Final LCA)	VS	54	Timber	42	CLT	56	2713
	HS	31	Windows and doors	14	Mortar	13	
	GF	11	Gypsum	14	Interior walls	12	
	Building technology	3	Insulation	11	Rockwool	11	
	OS	1	Floor (undefined)	8	Carpets	8	

NS 3451 - Table of Building Elements	
1 digit building element	2 digits building element
2 - Building	20 - Building in general 21 - Ground and foundation 22 - Structural system 23 - External walls 24 - Interior walls 25 - Slab 26 - Roof 27 - Building inventory 28 - Stairs and balcony 29 - Other building related parts
3 - Plumbing installations	30-39: out of scope of this study
4 - Electrical Power	40-49: out of scope of this study
5 - Telecom and automation	50-59: out of scope of this study
6 - Other installations	60-69: out of scope of this study
7 - Outdoor area	70-79: out of scope of this study

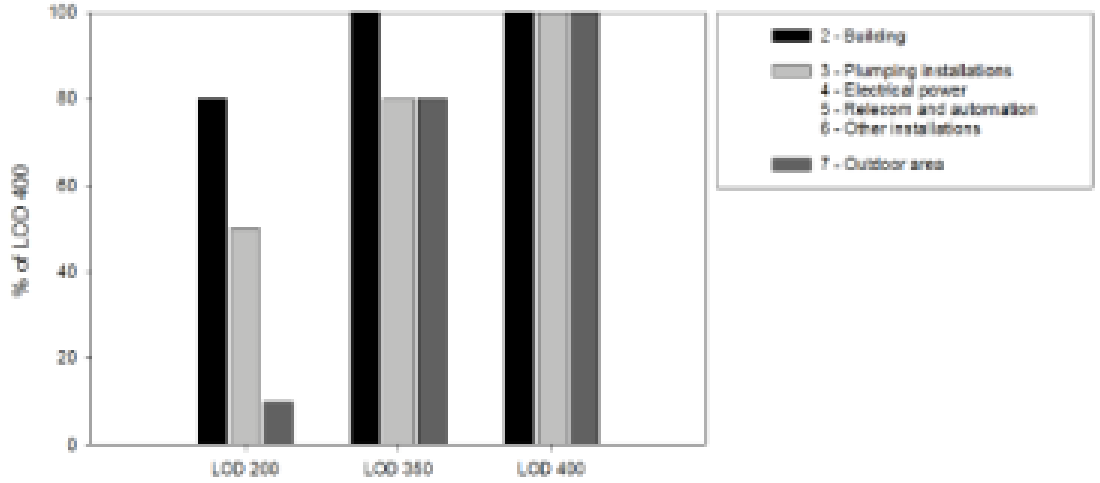
NS 3451 - Table of building elements

Construction categories divided with respect to LOD		
OCL main distributions	NS 3451	LOD
1) Ground and foundation	20	100
	21	150
2) Vertical structures and facade	22	175
	23	175
	24	175
3) Horizontal structures	25	175
	26	200
4) Other structures and materials	27	300
	27	300
	29	350
6) Building technology	3	350
	4	350
	5	350
	6	400
5) Outdoor area and elements on site	7	400

Construction categories divided with respect to LOD and its milestones



Design phase evolution according to LOD



Degree of completeness in different stages of LOD

LOD	NS 3451 (1 digit)	% of LOD 400	LCIA database for building elements
LOD 200	2	80	Average values, mean values, min/max values, most likely value
	3, 4, 5, 6	50	
	7	10	
LOD 350	2	100	EPD-Norway
	3, 4, 5, 6	80	Average values, mean values, min/max values, most likely value
	7	80	
LOD 400	2	100	EPD-Norway
	3, 4, 5, 6	100	
	7	100	

Level of completeness and LCIA databases

Conclusion

- Main aims of a BIM based LCA is to establish a convenient decision-making method with an environmental perspective, and an ongoing environmental assessment during the early design stages. Investing more time in the design stages and utilize LOD and its requirements consistently, would enhance the level of information and detail in BIM objects. This amplifies the information within the IFC files and leads to fewer errors in BIM-LCA tools.
- Therefore, we suggest the designers and design tools to be acquainted with the requirements to each LOD levels, and consequently use average, mean (±) values and best practice where the LOD level is low. The proposed LCA framework is corresponding to LOD levels, as the design delivery phases are determined by milestones of completeness in the BIM model.
- Designing the building project in BIM in accordance with this framework will improve the GWP, as interaction with BIM and LCA tools enables substitution of materials that contribute to the highest release of CO2. Such automation in LCAs, and the ability for ongoing assessments will assist the decision-making processes to emphasize the environmental issues during design.


Thank you.....
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