Appendix – Data

1 Introduction

This appendix aims to document the values used in the UrbanLCA tool to estimate greenhouse gas emissions and biodiversity loss from entire urban areas. Since this is a new calculation method, with biodiversity calculations being particularly novel for the industry, the values are based on a limited data foundation and are therefore associated with a certain degree of uncertainty. The values should thus be applied and interpreted in this context. However, the values used in the UrbanLCA tool provide a foundation for discussion and future qualification of the data.

2 Greenhouse Gas Emissions (GWP)

2.1 **Buildings** (In the tool: **Architecture**)

In recent years, there has been an increased focus on building LCA, which has resulted in the development of several databases at the building material level, as well as the publication of various reports summarizing results at building level.
In the UrbanLCA tool, the user can input their own data if specific information is available for the particular building or buildings. If such specific data is not available, the tool offers key figures based on the building's typology, activity and emission class.
In the tool, the following activities can be selected:

- Demolition
- Light transformation/renovation
- Moderate transformation/renovation
- Deep transformation/renovation
- Preservation
- New Construction

The transformation and renovation categories in the UrbanLCA tool are based on calculations from the scenarios in the publication "*Klimadata for renovering*" by Arkitema, COWI, BUILD and Rådet for Bæredygtigt Byggeri. [1]

The buildings in the UrbanLCA tool are divided into different building typologies, which are also described in BUILD's publication "*LCby*" [2]. This publication presents an assessment of what a tool for urban areas should include.

The typologies introduced in the UrbanLCA tool include:

- Residential – Single house
- Residential – Apartment
- Residential – Row housing
- Office / commercial
- Education
- Health
- Daycare institution
- Other

Furthermore, the tool offers three options for parking solutions:

- Parking basement
- Parking house
- Parking on ground

Finally, the user can define an emission class, with the option to choose from six different levels. The levels are listed below and explained in the following sections.

- Business as usual
- Building regulation 2025
- Low emission class (BR25)
- Reduction Roadmap 2.0 (2025, 2027 and 2029)

It should also be noted that the values used for the LCA phase B6 (operational energy use) are based on the latest emissions factors valid from July 2025 [3]. Similarly, it should be noted that the contribution from replacement (B4) is assumed to be evenly distributed over the building's 50-year evaluation period and does not appear in specific years. This is because the climate impact from replacements varies across buildings over their lifetime, which is why, for the sake of simplification, it is considered evenly distributed.

2.1.1 New Construction

2.1.1.1 Business as usual

For the *New Construction* category, the most comprehensive data foundation is available. Table 6 in the report "*Klimapåvirkning fra nybyggeri*" by BUILD [4] forms the basis for the phases A1-A3, B4, B6, C3-C4 for the emissions class *business as usual*. The table is presented here as Table 1:

Table 1. Overview of 25%, 50% and 75% percentiles across building typologies for total, building components and operational energy use.

	Total (A1-3, B4, B6, C3-4)			Bygningsdele (A1-3, B4, C3-4)			Drift (B6)		
[kg CO_2-ækv/m^2/år, 50 år]	Nedre	Median	Øvre	Nedre	Median	Øvre	Nedre	Median	Øvre
Enfamiliehus	7,99	8,89	10,01	7,18	8,31	9,07	0,61	0,70	1,06
Etagebolig	7,68	8,47	9,94	7,12	7,94	9,40	0,52	0,56	0,59
Rækkehus	7,32	8,19	8,79	6,39	7,39	8,24	0,54	0,64	0,90
Kontor	8,33	9,46	10,19	7,35	8,52	9,21	0,88	0,91	0,97
Daginstitution	8,06	9,31	9,70	7,11	8,31	8,87	0,77	0,92	0,99
Undervisning	11,31	11,55	12,59	10,37	10,69	11,80	0,83	0,84	0,90
Sundhedshuse	10,30	10,55	11,66	9,39	9,59	10,63	0,91	0,96	1,01
Andet	9,02	10,28	11,70	8,06	9,23	10,70	0,86	0,97	1,23

For the parking solutions in the LCA tool, Artelia's own database forms the basis for the values in Table 2. The analysis is based on 11 concrete parking basements and 4 parking houses in concrete and wood. For parking on ground, no LCA calculation is available, which is why the impact has not been assessed therefore does not appear in the tool.

Table 2. Overview of 25%, 50% and 75% percentiles for different parking solutions distributed across LCA phases.

	A1-A3			**C3-C4**		
kg $CO_2e/m^2/yr$, 50 yr	25%	50%	75%	25%	50%	75%
Parking basement	8,8	10,9	12,9	0,3	0,6	1,1
Parking house	2,8	3,1	3,4	0,1	0,1	0,2
Parking on ground	-	-	-	-	-	-

Since from 2025, requirements will be introduced in the Building Regulation for the construction process phases (A4-A5), it is desired that these values also are included in the UrbanLCA tool. The report "*Ressourceforbrug på byggepladsen*" by BUILD [5] has specifically assessed these phases and their climate impact. Table 15 in the report, reproduced here as Table 3, forms the basis for A4-A5 for all building typologies in the UrbanLCA tool.

Table 3. Key figures for climate impact in kg $CO_2/m^2/yr$ for LCA phases A4 and A5. The result is based on case analyses and estimated constants.

Modul	**Delemne**	**0,25 kvantil**	**0,50 kvantil**	**0,75 kvantil**	**0,90 kvantil**
		[kgCO_2e/m^2 år]			
A4	Transport af byggevarer	0,187	0,348	0,409	0,494
	Transport af spild [(1)]		0,020		
	Transport af materiel [(1)]		0,020		
	Terminalprocesser [(1)]		0,020		
	Sum A4	0,247	0,408	0,469	0,554
	El	0,068	0,143	0,196	0,262
	Varme	0,045	0,081	0,028	
	Brændstof	0,036	0,157	0,264	0,383
	Byggeaffald	0,407	0,536	0,753	1,042
	Bortkørsel af jord [(1)]		0,060		
	Bortkørsel af byggeaffald [(1)]		0,060		
	Sum A5	0,713	1,016	1,302	1,720
A4 + A5		0,960	1,424	1,771	2,274

1) Konstanter baseret på kvalificeret skøn.

2.1.1.2 Building Regulation 2025

For the category Building Regulation 2025' (BR25), the starting point is the limit values that will become mandatory from July 2025 [6]. The limit values are divided by building typologies and presented in the appendix agreement's Table 2, and reproduced here in Table 4.

Table 4. CO_2e limit values for new construction divided by building typologies, as of July 1, 2025.

Kg CO_2e/m^2/år	2025
Grænseværdi for bygninger	**7,1**
Ferieboliger under 150 m^2	4,0
Enfamiliehuse, rækkehuse og tiny houses samt ferieboliger på mindst 150 m^2	6,7
Etageboliger	7,5
Kontorbygninger	7,5
Institutioner	8,0
Andet nybyggeri	8,0
Selvstændig grænseværdi for byggeproces	1,5
Grænseværdi inkl. byggeproces	**8,6**

To distribute the climate impact across the included LCA phases, the same percentage distribution for phases A1-A3, B4, B6 and C3-C4 has been applied as for the *business as usual*-category. The LCA phases A4-A5 are listed separately in Table 4 and are included with corresponding values in the UrbanLCA tool.

2.1.1.3 Low Emission Class 2025

The appendix agreement also specifies limit values for the Low Emission Class. These values are similarly distributed across the LCA phases and carried forward to the UrbanLCA tool. The limit values can be found in Table 3 of the appendix agreement, and below in Table 5:

Table 5. CO_2e limit values for new construction in the Low Emission Class for different building typologies, as of July 1, 2025.

Kg CO_2e/m^2/år	2025
Grænseværdi for bygninger	**5,8**
Ferieboliger under 150 m^2	3,2
Enfamiliehuse, rækkehuse og tiny houses samt ferieboliger på mindst 150 m^2	5,4
Etageboliger	6,1
Kontorbygninger	6,1
Institutioner	6,4
Andet nybyggeri	6,4
Selvstændig grænseværdi for byggeproces	1,1
Lavemssionsklasse inkl. byggeproces	**6,9**

2.1.1.4 Reduction Roadmap

For the emission classes specified by the Reduction Roadmap, the limit values established in *Reduction Roadmap 2.0*, developed by Effekt, Artelia and CEBRA [7]. *Reduction Roadmap* described the necessary reduction in the building's climate burden to ensure that the 1,5°C target of the Paris Agreement is not exceeded, determined with a 50% probability, as shown in Figure 1.

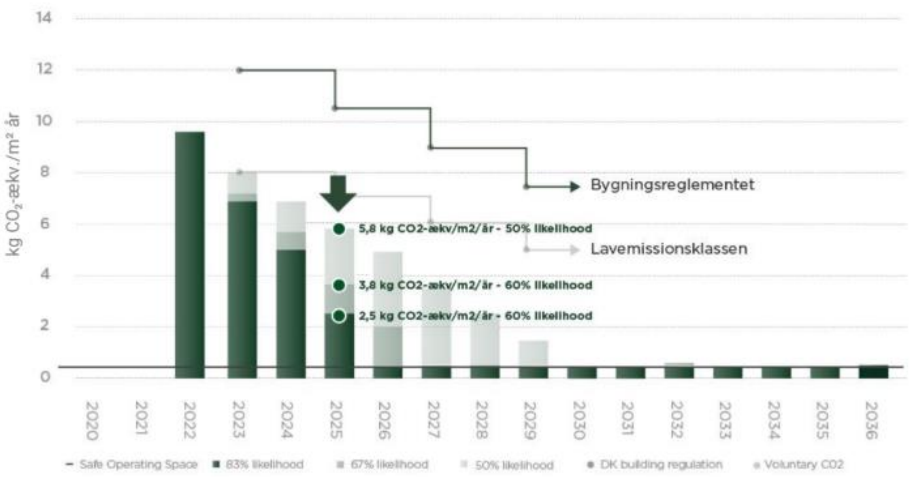


Figure 1. The reduction pathway from Reduction Roadmap 2.0 at different probabilities of compliance with the Paris Agreement's 1,5°C target.

Since different building typologies have varying reduction potentials, differentiated limit values are used as shown in Figure 2:

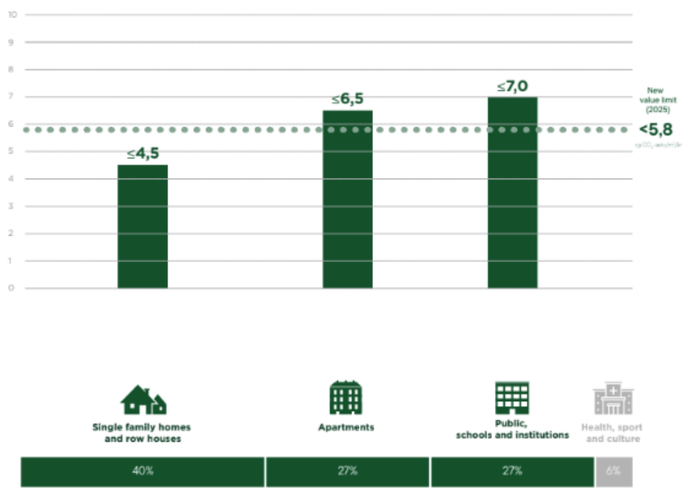


Figure 2. Differentiated limit values for the year 2025 for different building typologies.

Other building typologies, which are not shown in Figure 2, are assumed to have an environmental impact corresponding to public buildings, schools, and institutions.

The limit values for Reduction Roadmap 2027 and 2029 are determined by a linear scaling of the 2025 values in relation to the reduction pathway in Figure 1. The limit values for the building typologies are distributed across the LCA phases as described in section 2.1.1.2.

The LCA phases A4 and A5 are not part of Reduction Roadmap 2.0, so the limit values for BR25 are also used for Reduction Roadmap 2025. To determine the value of A4 and A5 in 2027 and 2029, the 2025 values are downscaled in relation to the reduction pathway in Figure 1

2.1.2 Transformation and preservation

In the work with UrbanLCA, the concepts of transformation and renovation are treated identically, although they actually cover different approaches to modifying or improving a building.

2.1.2.1 Business as usual / Building Regulation 2025

On the renovation and transformation front, available data on the climate impact are limited. However, the Realdania project "*Klimadata for renovering*" [1] has attempted to estimate the climate impact of various levels of renovation for residential buildings. In their work, four scenarios have been established: preservation, light renovation, moderate renovation, and deep renovation. These four categories have been reused in the work with UrbanLCA. For descriptions of the scenarios, refer to the report.
In the work with *Klimadata for renovering*, the buildings are divided into traditional and modern buildings. For the business as usual category in the UrbanLCA tool, data on the renovation/transformation of traditional buildings is used, while for the Building Regulation 2025 category, data for modern buildings is applied.
The complete overview of LCA results for typologies and renovation scenarios can be seen in *Klimadata for renovering* Table 32, while a modified overview used in the UrbanLCA tool is presented in Table 6.

Table 6. Overview of LCA results for all typologies, periods, and renovation scenarios, split on LCA phases and total in kg $CO_2e/m^2/yr$.

Typology	Period	ID	Degree of renovation	LCA phases				
				Ex. C3-C4	A1-A3	B4	B6	C3-C4
Single house	Tradiational	PTB	Baseline	-	-	0,56	4,10	As new built
		PTL	Light renovation	0,01	0,01	0,45	3,80	
		PTM	Moderate renovation	0,25	0,27	0,41	1,69	
		PTD	Deep renovation	0,25	0,44	0,42	1,13	
	Modern	PMB	Baseline	-	-	1,06	2,44	
		PML	Light renovation	0,01	0,15	0,72	1,95	
		PMM	Moderate renovation	0,25	0,70	0,97	1,14	
		PMD	Deep renovation	0,25	0,87	0,98	0,85	
Row housing	Tradiational	PTB	Baseline	-	-	0,77	3,09	
		RTL	Light renovation	0,02	0,01	0,62	2,80	
		RTM	Moderate renovation	0,38	0,40	0,59	1,72	
		RTD	Deep renovation	0,38	0,79	0,60	0,98	
	Modern	RMB	Baseline	-	-	1,09	2,32	
		RML	Light renovation	0,02	0,13	0,87	1,96	
		RMM	Moderate renovation	0,55	0,77	0,81	1,35	
		RMD	Deep renovation	0,55	1,30	0,83	0,97	
Apartments	Tradiational	ETB	Baseline	-	-	1,02	2,97	
		ETL	Light renovation	0,02	0,04	0,87	2,59	
		ETM	Moderate renovation	0,16	0,25	0,90	2,49	
		ETD	Deep renovation	0,16	0,44	0,91	1,30	
	Modern	EMB	Baseline	-	-	0,83	1,98	
		EML	Light renovation	0,06	0,10	0,61	1,71	
		EMM	Moderate renovation	0,11	0,39	0,76	1,07	
		EMD	Deep renovation	0,11	0,51	0,77	0,88	

Since the report does not address the construction process (A4-A5) in relation to renovation/transformation, these phases have been estimated in the work with the UrbanLCA tool. It is assumed that the climate impact from A4-A5 for renovation/transformation represents the same percentage share as the climate impact from phases A1-A3 for renovation/transformation represents of A1-A3 for new construction.

In a similar manner, the climate impact from renovation/transformation of building typologies other than residential buildings has been estimated in the UrbanLCA tool. For all phases, an average value is used, determined from the share that each LCA phase for the renovation/transformation of detached houses, row houses and apartment buildings, represents of the corresponding phases for new construction. For example, A1-A3 for deep transformation represents 8,3%, 8,7% and 16,7% of A1-A3 for the corresponding categories in new construction. The mean value (11,2%) is then used as a factor to scale the value from A1-A3 from new construction to the transformation/renovation of, for example, an office building.

2.1.2.2 Low Emission Class 2025 and Reduction Roadmap

To estimate the environmental impact of transformation for the Low Emission Class 2025 and Reduction Roadmap scenarios, a proportional estimation has been made. The values for LCA phases A1-A3, A4-A5, B4, and B6 for the transformation of modern buildings have been determined by proportionally scaling from the limit values for new construction. For example, A1-A3 for deep transformation represents 16.7%, 6.4%, and 36.4% of A1-A3 for new construction, respectively. The mean value (22.6%) is multiplied by the value for A1-A3 for new construction for the specific sustainability class.
The values for C3-C4 are the same as the emissions for new construction.

2.1.3 Demolition

For demolition scenarios, across all emission categories, only the LCA phases C3-C4 for the existing building stock are included. It is assumed that the emissions are the same as for new construction.

2.2 Vegetation (In the tool: **Softscapes**)

The UrbanLCA tool uses a simple approach to assess the impact of softscapes on the CO_2 balance in an urban area. Only CO_2 sequestration in the LCA phase B1 (use) is included, as limited data is available for the other phases. The C3-C4 phases for the existing softscapes are not included, as these are highly dependent on how long the softscape has been absorbing CO_2, as well as how the softscape is used after removal. The sequestration is calculated as an average annual value, even though in practice it often varies over the lifetime of the softscapes.

In the UrbanLCA tool, the user has the option to enter their own data if specific information about the softscapes is available. If such data is not available, the tool provides key figures based on the type of softscapes, its activity, and carbon sequestration potential.

The user can choose from the following activities in the tool:

- New Construction
- Preservation
- Demolition

Additionally, the following types of softscapes can be selected:

- Forest
- Grassland
- Mowed lawn
- Shrubland
- Meadow
- Wetland
- Garden
- Green facade
- Green roof
- Water area
- Tree

Finally, the user can define a carbon sequestration potential in the tool. Three categories are provided:

- High
- Moderate
- Low

Each of these categories is elaborated on below.

2.2.1 New Construction

The data foundation for softscapes CO_2 sequestration in the use phase is limited. There are a few scientific studies that have investigated carbon sequestration for specific types of softscapes, but the overall body of knowledge is sparse. It is also important to note that some of these studies concern conditions that may not necessarily be comparable to Danish conditions.

For some of the defined types of softscapes, it has not yet been possible to find data on CO_2 sequestration. Therefore, these have temporarily been excluded from the UrbanLCA tool. However, the Plan22+ Foundation has facilitated the *LCAlandskab* project, which is being developed by SLA Architects, BUILD, and Aaen Engineering. It is expected that this project will provide data that can be integrated into the UrbanLCA tool's tabs for Softscapes and Hardscapes.

Based on the current data foundation, Table 7 provides estimated CO2 sequestration rates for different types of softscapes.

Table 7. CO_2 sequestration rates from various types of softscapes and associated sources.

Type of vegetation	CO_2 uptake [kg CO_2-e/m²/yr]			Source
	High	Moderate	Low	
Forest	**2,12**	**1,49**	**0,86**	[8]
Grassland	**0,40**	**0,22**	**0,11**	[9]
Mowed lawn	**0,34**	**0,25**	**0,17**	[10]
Shrubland	**0,32**	**0,20**	**0,16**	[11]
Meadow	**0,85**	**0,43**	**0,27**	[12]
Wetland	**0,46**	**0,28**	**0,16**	[13]
Garden	**0,33**	**0,33**	**0,33**	[14]
Green facade	**-**	**-**	**-**	-
Green roof	**0,31**	**0,31**	**0,31**	[15]
Water area	**-**	**-**	**-**	-
Tree	**1,70**	**1,14**	**0,85**	[16]

2.2.2 Preservation

For preservation, the same annual CO_2 sequestration rates as for new construction are used, according to Table 7. In practice, however, the annual sequestration will vary compared to new constructions, depending on the age of the softscape. To ensure simplicity in the UrbanLCA tool, this simplified approach is used.

2.2.3 Demolition

Emissions from the demolition of softscapes are not included in the UrbanLCA tool.

2.2.4 **Paving** (In the tool: **Hardscapes**)

To estimate the environmental impact from hardscapes, the tool "*InfraLCA*", developed by Vejdirektoratet, is used as input for the UrbanLCA tool. *InfraLCA* contains a range of typical paving materials that the user can combine to create a hardscape.
The user also has the option to enter their own data if specific information about the hardscape is available. If such data is not available, the tool provides key figures based on the type of hardscape and activity. The tool is also prepared to categorize hardscape types into categories with high, moderate, or low environmental impact. However, the current data foundation is still too limited to enable detailed categorization.

The user can choose from the following activities in the tool:

- New construction
- Preservation
- Demolition

The following types of hardscapes can then be selected:

- Asphalt T0 (only light vehicles)
- Asphalt T1 (less than 1 truck per day)
- Asphalt T2 (up to 65 trucks per day)
- Asphalt T3 (between 65 and 120 trucks per day)
- Asphalt T4 (between 120 and 560 trucks per day)
- Asphalt T5 (between 560 and 1200 trucks per day)
- Brick
- Cobblestones
- Pavers
- Gravel
- Armed grass

As previously described, the user can choose from the following environmental impact categories:

- High
- Moderate
- Low
- Reused

The values for the high, moderate, and low environmental impact categories, as described earlier, do not have different values due to a lack of data. The *Reused* category is included with the assumption of direct reuse, where emissions in the LCA phases are set to zero.

A detailed description of each category follows below.

2.2.5 New construction

In the UrbanLCA tool, the LCA phases A1-A3, A4-A5, and C3-C4 are included for hardscapes. The environmental impact for breaking up existing hardscapes is equated with the value for the C3-C4 phases for a new construction. In the current version of the tool, no distinction is made between high, moderate, and low environmental impact levels for the hardscapes.

Artelia's specialists in construction projects have identified several typical hardscape constructions, which, along with actual constructions from the Frederiksberg Hospital site, form the basis for the constructions the user can choose from in the UrbanLCA tool. Table 8 presents these constructions along with the associated emission values distributed across LCA phases.

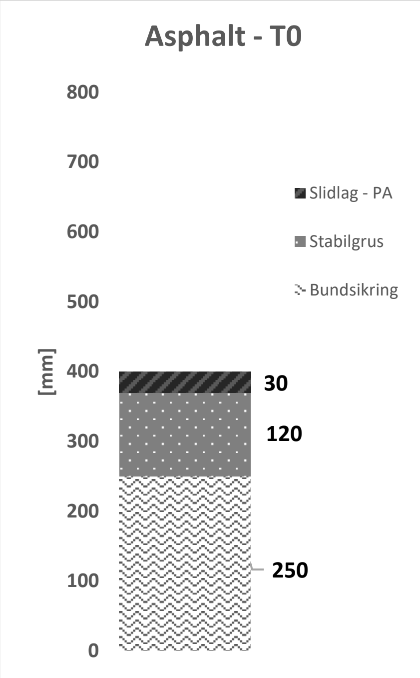
2.2.6 Preservation

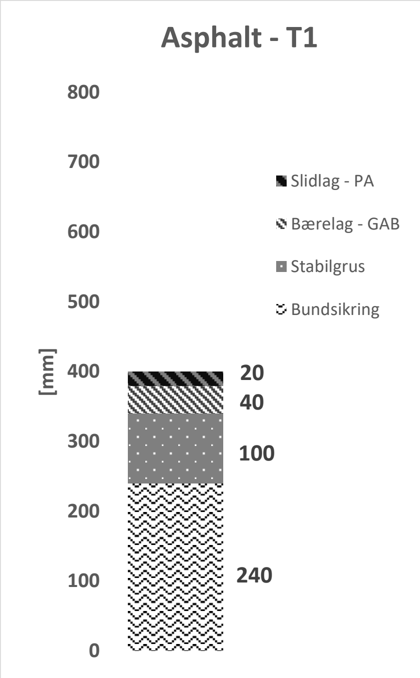
For the preservation of existing hardscapes, only the contribution from C3-C4 is included, as with new construction, since the hardscapes will still need to be disposed of at a later stage.

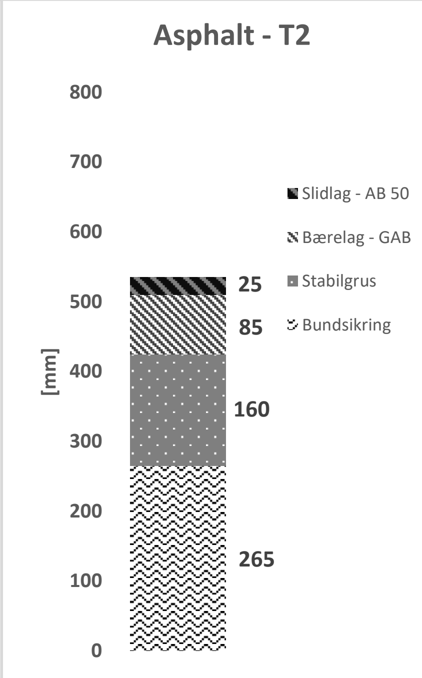
2.2.7 Demolition

For the demolition of hardscapes, the same emission values for the LCA phases C3-C4 are used as for new construction.

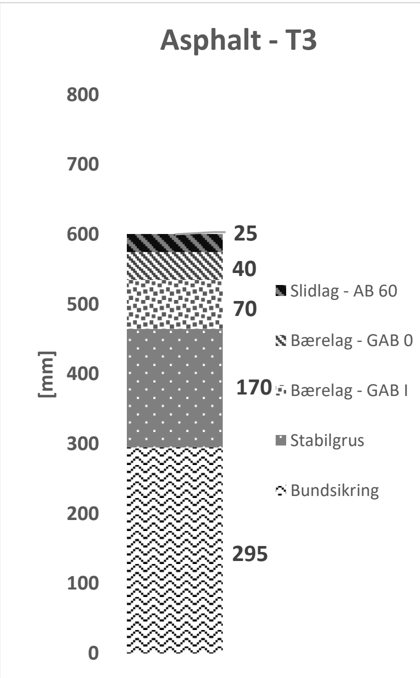
Table 8. Different hardscapes with associated emission values in kg $CO_2e/m^2/yr$.

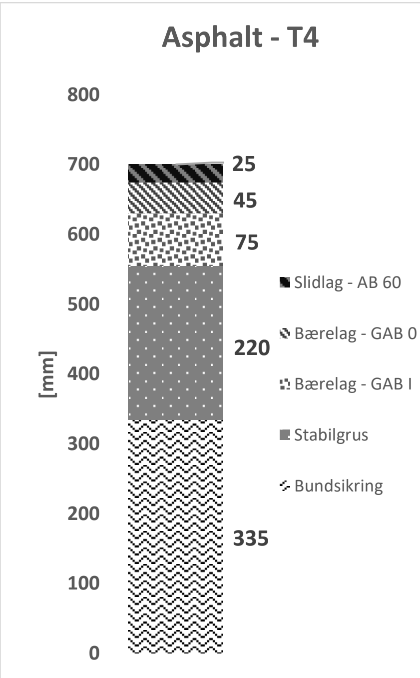


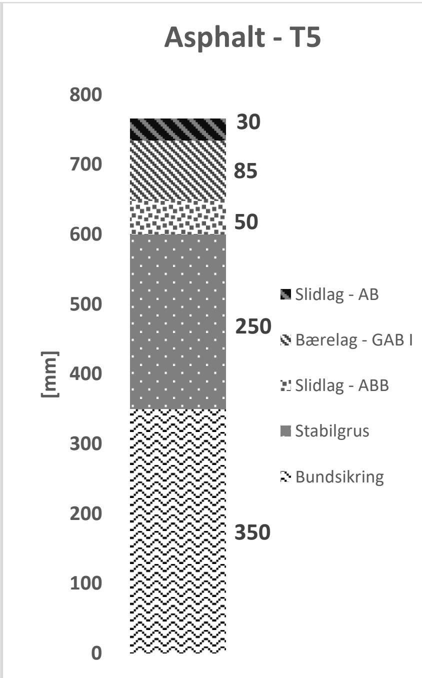




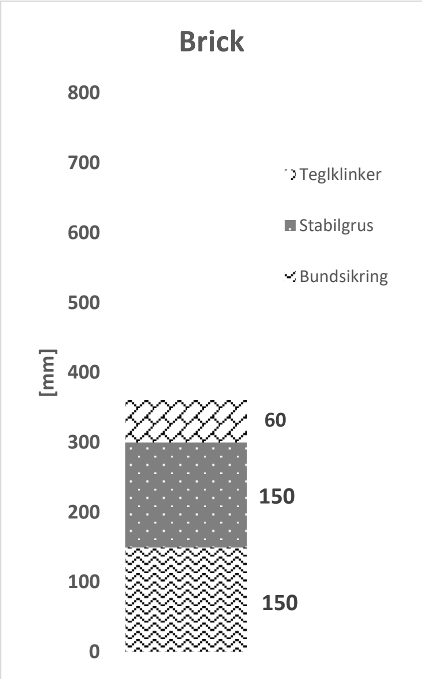
A1-A3	A4-A5	C3-C4	A1-A3	A4-A5	C3-C4	A1-A3	A4-A5	C3-C4
0,11	0,33	0,005	0,16	0,33	0,001	0,26	0,44	0,02

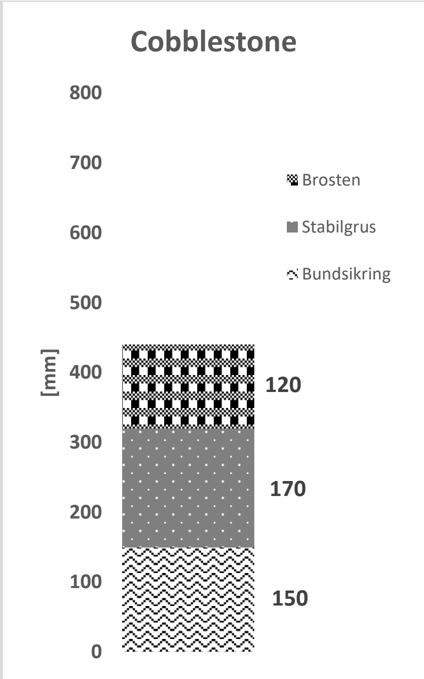


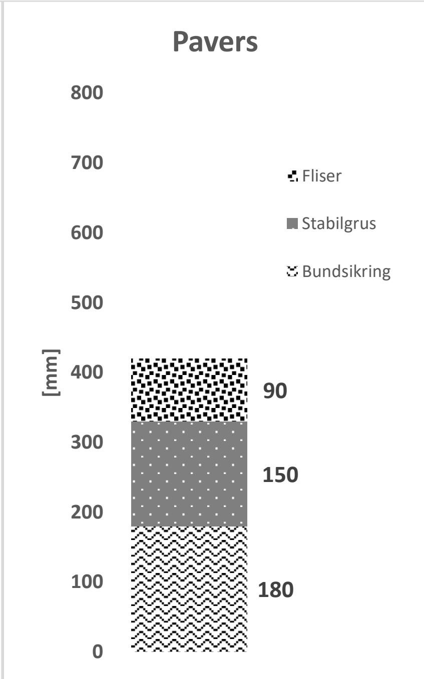




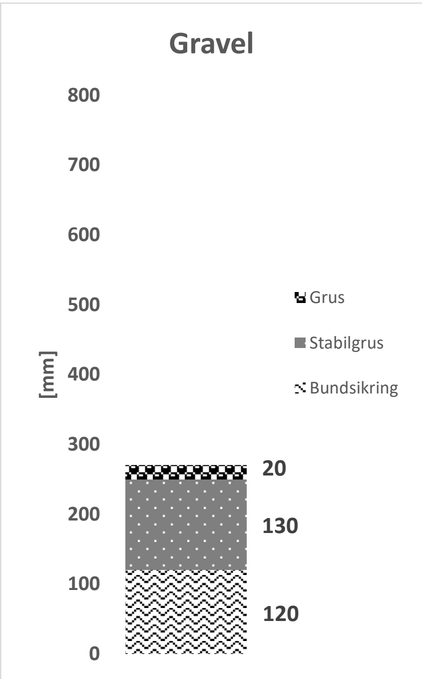
A1-A3	A4-A5	C3-C4	A1-A3	A4-A5	C3-C4	A1-A3	A4-A5	C3-C4
0,31	0,49	0,02	0,34	0,58	0,02	0,39	0,63	0,02

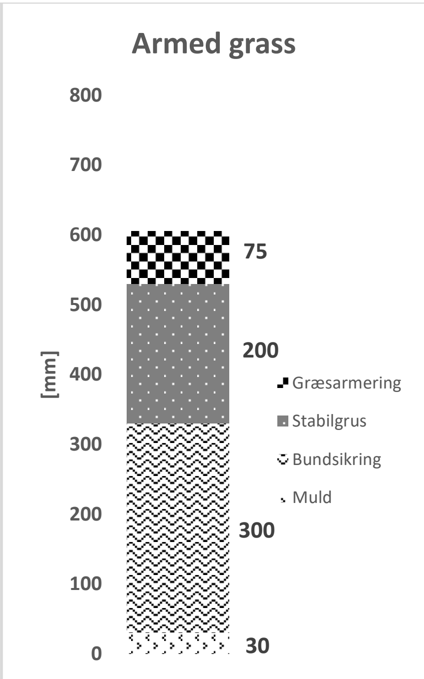






A1-A3	A4-A5	C3-C4	A1-A3	A4-A5	C3-C4	A1-A3	A4-A5	C3-C4
0,36	0,25	0,01	0,72	0,58	0,02	0,50	0,34	0,02





A1-A3	A4-A5	C3-C4	A1-A3	A4-A5	C3-C4
0,04	0,23	0,0004	0,09	0,42	0,01

2.3 **Forsyninger** (I værktøjet: **Utilities**)

The environmental impact from external utilities is included for pipes/lines and associated excavation work. However, it has not been possible to find data for utility infrastructure such as transformer stations, heating plants, or retention basins, which is why these are not included in the UrbanLCA tool.
However, a *Plan22+* project *ForsyningsLCA* has been initiated, where several utility companies are collaborating to develop emission values for utility infrastructure. Once this project is completed, it is expected that the data provided will be integrated into the UrbanLCA tool.

As with the other elements in the UrbanLCA tool, the user can combine an activity, construction, and environmental impact.

In the tool, the user can choose from the following activities:

- New construction
- Preservation
- Demolition

Currently, the UrbanLCA tool includes the following types of utilities:

- District heating pipe
- Service water pipe
- Waste water pipe
- Rain water pipe
- Electric cables

The user can choose from the following environmental impact categories:

- High
- Moderate
- Low

The values for the high, moderate and low environmental impact categories are currently identical, as there is insufficient data to differentiate them.

A detailed description of each category follows below.

2.3.1 New construction

To estimate the emission values for utility pipes, a case from Frederiksberg has been used, where the installation includes 200 meters of Ø168 district heating pipe, 200 meters of Ø110 service water pipe, and 128 meters of waste water pipe with varying dimensions. Emilie Berg Hansen, in her master's thesis, estimated the environmental impact of the processes involved in the installation of these utility pipes using *InfraLCA*. The calculations include the production of pipes and pipelines, excavation of soil, breaking and reinstallation of existing asphalt and roadbed, and construction of backfill.

To convert the case-specific values into simple and useful key figures that can be used in the early design phases, where the dimensions of pipes and pipelines have not yet been determined, the values have been downscaled to include typical average pipe sizes. The basis for this is an extract of existing pipes on the Frederiksberg Hospital site, which has formed the foundation for calculating an average pipe size for the different pipe types.

Table 9 summarizes the emission values, distributed across phases, for the different pipe types.

Table 9. Emission values for various pipe types used in the UrbanLCA tool.

Type of pipe	Emission values [kg CO_2e/m/yr]		
	A1-A3	A4-A5	C3-C4
District heating pipe	0,71	0,61	0,06
Service water pipe	1,32	0,72	0,11
Waste water pipe	1,77	1,00	0,14
Rain water pipe	1,77*	1,00*	0,14*
Electric cables	0,39	0,56	0,02

*The emissions for the rain water pipes are considered to be identical as the waste water pipes.

Table 9 also shows the emission values for electrical cables. The case for the district heating pipe has been used as the basis, where the excavation work is assumed to be identical, while the district heating pipe is replaced with a specific electrical cable.

2.3.2 Preservation

For the preservation of existing pipes and cables, only the contribution fro C3-C4 is included, since the pipes and cables will still need to be demolished of at a later stage. The climate impact is assumed to be the same as for new installation.

2.3.3 Demolition

For the demolition of pipes and cables, the climate impact from the LCA phases C3-C4 is assumed to be the same as for new installation.

2.4 Mobility

Mobility is included in the UrbanLCA tool as the use of cars, trains, buses, and bicycles by people in an urban area. In the beta version of the tool, mobility data is based on data from Frederiksberg. Users of the tool are encouraged to overwrite these values with specific and up-to-date data from their own area. Since *TrafikVaneUndersøgelsen* (TU) has closed data, which is only available via subscription, data for all areas are not integrated into the tool.

The background data forms the basis for the mobility calculations in the tool. To allow the user to examine different mobility measures, data from *Turrater* [17] has been used to adjust the background data. This enables the user to analyze the following measures:

- Parking norm
- Car ownership
- Parking restrictions
- Proximity to station

Additionally, the user can adjust the expected share of bicycles, which reduces the amount of other transport forms linearly.

The emissions factors for **cars** and **buses** have been determined COWIs report "*Emissionsfaktorer for vejtransport frem mod 2080"* [18], from where the data in Table 10 comes from.

Table 10. Emission factors for car and bus transport in g/km.

	2020	2030	2040	2050	2060	2070	2080
Car	142,8	115,2	79,7	38,6	8,9	1,7	1,3
Bus	695,5	633,5	517,8	293,9	107,2	26,7	7,9

To account for varying passenger capacity, the emission factors are converted to the unit "g/person km". The user can enter the expected average number of people per car in the tool, while calculations for buses are based on a typical bus with 54 seats and an occupancy rate of 63%, as stated in COWI's report "*Sammenligning af emissionsfaktorer*" [19].

Linear interpolation has been used between the years in Table 10, and an average value for the period 2025 to 2074 has been used as the emission factor for all calculation years in the UrbanLCA tool.

For **trains**, an emission value of 27 g/person km for the year 2020 [19]. The projection of train emissions follows the same percentage reductions as for buses in Table 10, according to COWI's report.

2.5 Biodiversity

Biodiversity in the UrbanLCA tool is divided into two categories: **on-site** og **off-site biodiversity**.

On-site biodiversity:
To assess on-site biodiversity, the approach is based on the method used in the latest DGNB manual from 2023 [20]. Whether the method actually promotes biodiversity in the local area or merely reflects the degree of greening is beyond the scope of this context to evaluate. However, the method is simple to use and already in practice, which has made it natural to implement it in the UrbanLCA tool.

Off-site biodiversity:
To estimate the off-site impact on biodiversity, there is a wide range of indicators, each highlighting different aspects of biodiversity. However, calculating the impact on biodiversity requires extensive data and analysis, which is challenging due to a relatively sparse data foundation.

Therefore, the decision has been made to use the indicator *material footprint*. This indicator is simple, as it only relates to the weight of the material used. The advantage of the material footprint is that the weight of the entire building is already calculated through the LCA process, eliminating the need for additional data collection for specific biodiversity calculations. The material footprint is an important indicator, as material extraction from terrestrial and marine ecosystems impacts land use changes, chemical loading, and biodiversity loss. While the material footprint is not a direct indicator of ecological impact, it is a well-known and widely used proxy in policy literature and has a solid empirical foundation for this purpose [21].

Furthermore, studies according to [22] show a high correlation (0.73) at the aggregated level between material footprint and ecological impact. This supports the use of material footprint as a practical and useful indicator in this context.

In the UrbanLCA tool, off-site biodiversity from **Architecture**, **Hardscapes**, and **Utilities** is included. Operational energy for the buildings is, however, excluded. **Softscapes** and **Mobility** are not part of the UrbanLCA tool.

The material footprint values for **Architecture** come from Artelia's LCA database for buildings, where the total weight of various buildings has been analyzed. Based on this data, a linear regression was performed to examine the relationship between GWP and material footprint for different building typologies. The developed regressions, for each building typologies, were subsequently used to estimate the total material footprint for the building typologies included in the UrbanLCA tool.

For **Hardscapes**, the material footprint values are based on the constructions listed in Table 8. For each layer in the constructions, its density is typically estimated from data in InfraLCA. In cases where densities are not available in InfraLCA, they have been estimated with input from various contractors in road and asphalt work.

Finally, the values for **Utilities** are estimated based on an existing case at the Frederiksberg Hospital site. Here, an average pipe size has been determined, and the weight of these pipes has been used as an indicator for the material footprint.

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