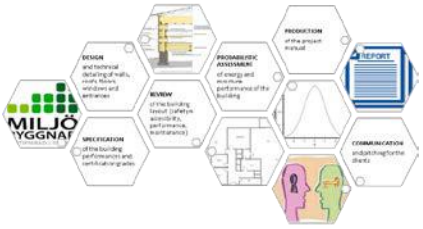


BOM175 Building technology engineering
Chalmers, MPSEB, 2020/2021
Responsible teacher, Pär Johansson
par.johansson@chalmers.se
Version: 2020-06-05

Project task in BOM175

Introduction

The design team should develop technical design options for a commercial building with mixed use, with spaces for commercial and office premises. The clients require a well-functioning, safe and efficiently maintained building, which fulfils the requirements for grade 'silver', at least, according to the certification system Miljöbyggnad (MB). The focus of the task is on the functional zoning, holistic design and performance of the building envelope and hygrothermal performance of the whole building.

Building lot. Located in Gothenburg, in the business and retail area Sisjön. It is of rectangular shape and surrounded by traffic on all sides. The key infrastructure includes electricity, water, sewage, district heating and internet connection. The building lot is large enough to accommodate both the building and parking lot.

Design drawings. Architectural proposals of the building layouts and floor plans for the ground and first floor can be found in Canvas. The proposed layouts should be carefully revised and, if necessary, re-arranged to answer in the best way to the project requirements.

Specifications

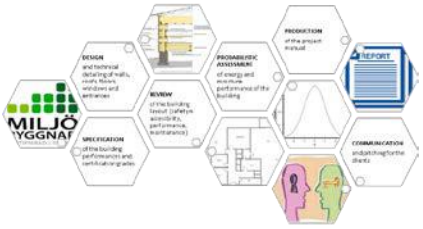
Commercial part of the building comprises a public area – the supermarket, and private areas with spaces for

- general storage,
- cold storage for chilled (+3 ^{o}C) and deep-frozen goods (-25 ^{o}C),
- working areas for cutting and packing of meat,
- technical room,
- staffrooms (for dining, changing, refreshing, for 10-20 persons),
- goods entrance,
- and transport corridors.

The public areas should be entirely located on the ground floor and the required free height is 8 m. The supermarket may be treated as one thermal zone.

Office part is on two floors, where the ground floor is shared between a bank and real-estate business, and the first floor has offices for administration, education and management. The ground floor is fragmented into a reception, cell-offices, a landscape office, a seminar room, staffrooms including changing-rooms and showers, a dining-room and a technical room.

The floor plans give settings for future extensions. A small vault and a computer server room are placed on the first floor. Computer security, protection against burglary, water damages and fire protection are given high priority. The construction height of the ground floor is 3.2 m and 2.9 m of the first floor.



Design targets in Miljöbyggnad

Miljöbyggnad (MB) [miljö = environmental, byggnad = building] is a Swedish building certification system, developed and adapted to the needs of the construction industry and property managers. Design, development and distribution of MB is facilitated by the Swedish Green Building Council (SGBC), whose ambition is to provide a scientifically based, yet easy to use, certification system. MB is regularly updated, and the latest version is 3.1.

A building is certified by the means of 'Indicators', which are either quantitative performance criteria or project documentation, and grouped in the following fields

- Energy
- Indoor environment
- Materials

Each Indicator can be graded as BRONZE, SILVER and GOLD. Bronze indicates that the building complies with the basic legal demands in the Swedish building regulations (BBR), and gold that the building has the most advanced performances and qualities. Individual grades are weighted within each field, and then to the final grade for the building. The grading is facilitated by the MB grading tool and validated 3 years after commissioning.

New produced buildings
Miljöbyggnad 3.1

MILJÖ BYGGNAD

Building	
Comment	

		Indicators in 3.0	Indicator	Aspect	Field	Building
Energy	1	Heating power demand	SILVER	SILVER	SILVER	SILVER
	2	Solar heat load	GOLD			
	3	Bought energy for basic op.	BRONZE	BRONZE		
	4	Fraction of renewables	SILVER	SILVER		
Indoor environment	5	Sound	GOLD	GOLD	SILVER	
	6	Radon	BRONZE	BRONZE		
	7	Ventilation	SILVER			
	8	Moisture safety	GOLD	GOLD		
	9	Thermal climate winter	BRONZE	BRONZE		
	10	Thermal climate summer	SILVER			
	11	Daylight	GOLD	GOLD		
	12	Legionella	BRONZE	BRONZE		
Materials	13	Logbook building materials	SILVER	SILVER	SILVER	
	14	Phasing out of hazard. sub.	GOLD	GOLD		
	15	Env. impact of build. structure	BRONZE	BRONZE		

MB 3.1 grading tool.

Specific targets for each indicator as well as calculation methodologies are described in the MB manual. This is a rather comprehensive document, which exists only in Swedish. For this course, a summary of the specific design targets and some explanations are prepared in the document 'Short explanation of MB 3.1 Indicators (in English)', provided on Canvas.

Miljöbyggnad

New Construction – Offices

DVUT - design outdoor temperature

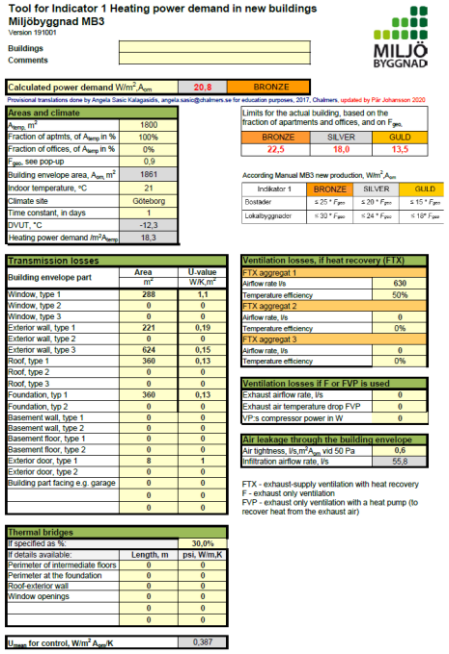
F_{geo} - factor, geographical location (see next page)

Issue	number	Indicator	BRONZE	SILVER	GOLD	Explanation
Energy	3	Bought energy	<= BBR	≤ 0,70*BBR	≤ 0,60*BBR	BBR = Swedish Building Code
	1	Heating power requirem.	≤ 30*F_{geo}	≤ 24*F_{geo}	≤ 18*F_{geo}	W/m² of A_{om} at DVUT
	2	Solar heat load	≤ 40 W/m² FA	≤ 32 W/m² FA	≤ 22 W/m² FA	FA = Floor Area
	4	Fraction of renewable energy	> 50% Cat 1	>75% Cat1 out of > 10% Cat 2 OR > 80% Cat 1	>80 % Cat1 with >5 % Cat 3	Cat1 - Renewables Cat2 - Renewable flowing Cat3 - Locally produced renewables
Indoor environment	5	Noise protection	≥ Sound Class C	≥ 50% of the parameters Class B	≥ Sound Class B 80% of users satisfied	Classes according to Swedish Standard 25267
	6	Radon content	101-200 Bq/m³	61-100 Bq/m³	≤60 Bq/m³	Maximum annual average
	7	Ventilation rates	≥7l/s,pers AND 0,35 l/m² FA	BRONZE + CO_2 only temporarily > 1000 ppm	Alt1: SILVER+approved questionnaire Alt2: local ventilation index >=90% or CO_2 only temporarily > 900 ppm	
		N_2O to indoor air (from traffic)	not considered in Miljöbyggnad 3.1			
	8	Moisture prevention	Moisture proof design according to BBR 6:5	+ Moisture proof design according to Bygga F	+ A certified moisture expert	BBR = Swedish Building Code Bygga F = specific method for moisture proof design
	9	Thermal climate winter	PPD ≤ 15% at DVUT	PPD ≤ 10% at DVUT	SILVER + approved questionnaire	PPD = Predicted Percentage Dissatisfied
	10	Thermal climate summer*	PPD<=15% on critical day	PPD<=10% on critical day	SILVER+questionnaire or measurements	
	11	Daylight	DF >= 0.8 %	DF ≥ 1.0 %	DF ≥ 1.3	DF = Daylight Factor; more on page 4
	12	Legionella	not considered in BOM175 ≥ 60°C in HWS. Demands on hot water pipes.	+ SWI is applied.	+ thermometers on all WWC-loops	HWS = Hot Water Storage SWI = Secure Water Installation (spec. insustry rules) WWC = Warm Water Circulation.
Material & chemicals	13	Logbook building materials	LB on building products	+ LB is digital	+ LB with amount and place for each prod.	LB = Log Book with product type, name, producer, year and content of substances
	14	Phasing out of hazardous substances	Less amount of listed products	+Some POS above content limits occur and are listed	+Prioritized POS only in small amounts +Below EU-LCI emission from BP	POS = Phase Out Substances according to Swedish Chemicals Agency. BP = Building products
	15	Environmental impact of the building's structural system and foundations is a new criterion in MB 3.0, not considered in the course BOM175				

in offices with cooling system

Specific design targets and documentation for each Indicator. The shaded fields are not regarded in the course, i.e. Indicators 5, 6, 12 – 15.

Besides the grading tool, MB provides Excel-based tools for Indicators 1 and 4. All tools are in Swedish and protected from changes to assure the quality of grading. All tools can be found in Canvas, as well as their provisional translation 'Translations of MB 3.1 Tools (Grading tool, Indicators 1 and 4).


Tool for Indicator 1 Heating power demand in new buildings
Miljöbyggnad MB3
Version 191001

Buildings
Comments

Calculated power demand W/m², A_temp — 20,8 — BRONZE

Provisional translations done by Angela Sasic Kalagasidis, angela.sasic@chalmers.se for education purposes, 2017, Chalmers, updated by Pär Johansson 2020

Areas and climate	
A_temp, m²	1800
Fraction of apt/rts, of A_temp in %	100%
Fraction of offices, of A_temp in %	0%
F_geo, see pop-up	0,9
Building envelope area, A_om, m²	1861
Indoor temperature, °C	21
Climate site	Göteborg
Time constant, in days	1
DVUT, °C	-12,3
Heating power demand /m²A_temp	18,3

Limits for the actual building, based on the fraction of apartments and offices, and on F_geo

BRONZE	SILVER	GULD
22,5	18,0	13,5

According Manual MB3 new production, W/m²,A_om

Indikator 1	BRONZE	SILVER	GULD
Bostäder	≤ 25 * F_geo	≤ 20 * F_geo	≤ 15 * F_geo
Lokalbyggnader	≤ 30 * F_geo	≤ 24 * F_geo	≤ 18* F_geo

Transmission losses		
Building envelope part	Area m²	U-value W/K,m²
Window, type 1	288	1,1
Window, type 2	0	0
Window, type 3	0	0
Exterior wall, type 1	221	0,19
Exterior wall, type 2	0	0
Exterior wall, type 3	624	0,15
Roof, type 1	360	0,13
Roof, type 2	0	0
Roof, type 3	0	0
Foundation, typ 1	360	0,13
Foundation, typ 2	0	0
Basement wall, type 1	0	0
Basement wall, type 2	0	0
Basement floor, type 1	0	0
Basement floor, type 2	0	0
Exterior door, type 1	8	1
Exterior door, type 2	0	0
Building part facing e.g. garage	0	0
	0	0
	0	0

Ventilation losses, if heat recovery (FTX)	
FTX aggregat 1	
Airflow rate l/s	630
Temperature efficiency	50%
FTX aggregat 2	
Airflow rate, l/s	0
Temperature efficiency	0%
FTX aggregat 3	
Airflow rate, l/s	0
Temperature efficiency	0%

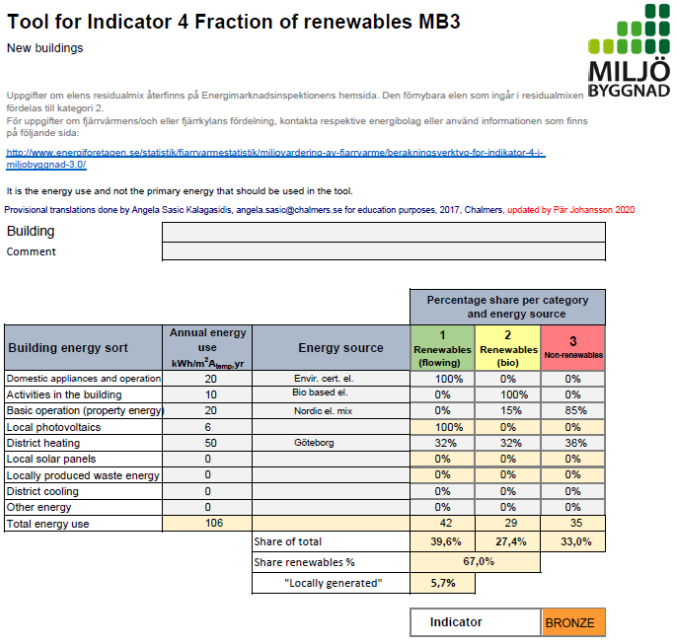
Ventilation losses if F or FVP is used	
Exhaust airflow rate, l/s	0
Exhaust air temperature drop FVP	0
VP:s compressor power in W	0

Air leakage through the building envelope	
Air tightness, l/s,m²A_om vid 50 Pa	0,6
Infiltration airflow rate, l/s	55,8

FTX - exhaust-supply ventilation with heat recovery
F - exhaust only ventilation
FVP - exhaust only ventilation with a heat pump (to recover heat from the exhaust air)

Thermal bridges		
If specified as %		30,0%
If details available:	Length, m	psi, W/m,K
Perimeter of intermediate floors	0	0
Perimeter at the foundation	0	0
Roof-exterior wall	0	0
Window openings	0	0
	0	0
	0	0

U_klimat for control, W/m²A_om/K — 0,387


Tool for Indicator 4 Fraction of renewables MB3
New buildings

Uppgifter om elens residualmix återfinns på Energimarknadsinspektionens hemsida. Den förnybara elen som ingår i residualmixen fördelas till kategori 2.
För uppgifter om fjärrvärmens/och eller fjärrkylans fördelning, kontakta respektive energibolag eller använd informationen som finns på följande sida:

http://www.energiforetagen.se/statistik/fjarrvarmestatistik/miljovardering-av-fjarrvarme/berakningsverktyg-for-indikator-4-i-miljobyggnad-3.0/

It is the energy use and not the primary energy that should be used in the tool.

Provisional translations done by Angela Sasic Kalagasidis, angela.sasic@chalmers.se for education purposes, 2017, Chalmers, updated by Pär Johansson 2020

Building
Comment

Building energy sort	Annual energy use kWh/m²A_temp,yr	Energy source	Percentage share per category and energy source: 1 Renewables (flowing)	2 Renewables (bio)	3 Non-renewables
Domestic appliances and operation	20	Envir. cert. el.	100%	0%	0%
Activities in the building	10	Bio based el.	0%	100%	0%
Basic operation (property energy)	20	Nordic el. mix	0%	15%	85%
Local photovoltaics	6		100%	0%	0%
District heating	50	Göteborg	32%	32%	36%
Local solar panels	0		0%	0%	0%
Locally produced waste energy	0		0%	0%	0%
District cooling	0		0%	0%	0%
Other energy	0		0%	0%	0%
Total energy use	106		42	29	35
		Share of total	39,6%	27,4%	33,0%
		Share renewables %	67,0%		
		"Locally generated"	5,7%		

Indicator	BRONZE

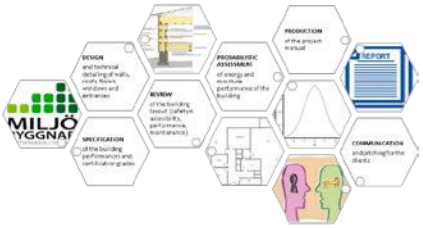
MB Excel-based tools for Indicators 1 and 4, translated to English.

MB Indicators of interest for this course

Building certification is a comprehensive work, which only can be done by licensed evaluators. Therefore, the aim of the project task is not to learn MB but to use it as a rationale and design framework that sets boundaries to our design tasks.

In this course, the design teams should cover nine out of the fifteen Indicators: 1, 2, 3, 4 (optional) 7, 8, 9, 10 and 11. Indicator 4 'Fraction of renewables' is optional because it includes characteristics of the energy supply network of Sweden that have not been covered in earlier courses. The team members may try to assign a grade to this Indicator by using 'MB 3.1 Tool for Renewables (Indicator 4)'. Otherwise, the grade for this and the remaining six indicators are to be presented as the project ambitions.

Note that you are supposed to use advanced simulation tools when studying the building performance – more details in the course memo.

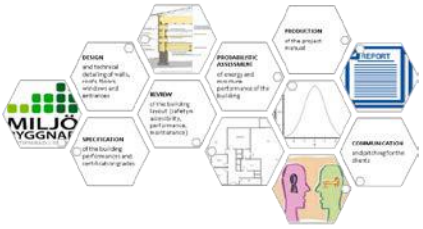


Deliverables

The design teams should document their research, design and assessment in a technical report. The mandatory items in the report are sections 1-6, as listed below[1]. The winning concept for the building will be presented to the clients on October 22. An example of a completed and well-executed report can be found in Canvas. Note that this report is only an example.

1.0	**Design program**		
	1.1	Environmental goals	
			Thermal comfort ambitions
			Daylight ambitions per zone
	1.2	Functionality	
			Access
			Safety
			Maintenance
2.0	**Building design**		
	2.1	Structural system	
	2.2	Building envelope	
			Walls
			Roof
			Floor
			Windows
	2.3	Air tightness	
	…		
3.0	**Energy performance of the building**		
	3.1	Building energy model used for simulations	
	3.2	Reference building and office	
	3.3	Bought energy	
	3.4	Heating power demand	
	3.5	Solar heat load	
4.0	**Indoor environment in the office part**		
	4.1	Thermal climate winter	
	4.2	Thermal climate summer	
	4.3	Daylight analysis	
5.0	**Fire safety design**		
			Fire compartments
			Evacuation routes
6.0	**Moisture performance of the building envelope**		
	6.1	Reference design, critical locations	
	6.2	MGI for the reference design	
	6.3	MGI, probabilistic assessment	

[1] See the project management tool – 'Weekly work plans - template HT20'



Some details on the deliverables

1.0 Design program. Environmental goals, both individual and total Miljöbyggnad grade based on Miljöbyggnad tools should be presented in the design program which should be based on a qualitative analysis of the layout and description on different functional zonings.

2.0 Building design. Conceptual drawings and descriptions of the parts of the building envelope should be presented. Detailed sections, relevant connections, materials and U-values of the different relevant parts of the building envelope. Show how the rainwater management from the roof works, i.e. position of gutters and down pipes. For air tightness, hand calculations of the air leakage n_{50} value and rate at working conditions should be presented. The n_{50} value should be assumed, as well as the working pressure difference, see 'Air infiltration and natural ventilation 2018.pdf ' on Canvas. The air leakage at normal operation should be used in the energy simulations.

3.0 Energy performance of the building. Describe the model capability. Draw a concept diagram, or similar, showing physical flows between components in the model. Calculate the annual energy demands for the basic and normal operation, split in heating, cooling, fans, lighting, tap water, elevator and other items of interest. You should also show the variability of the results for normal operation by considering at least three alternative designs; e.g. a) if no heat exchanger is applied, b) if the thermal inertia is reduced (see 'Thermal inertia of buildings 2018.pdf ' on Canvas), c) if no solar shading is used, d) reduced/increased U-values, etc. All results should be summarized in bar charts.

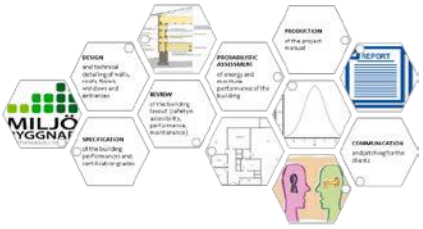
The power demand should be calculated for the basic and normal operation, split in heating and cooling. You should also show the variability of the results by considering at least three alternative designs, e.g. a) if no heat exchanger is applied, b) if the thermal inertia is reduced (see 'Thermal inertia of buildings 2018.pdf ' on Canvas), c) if no solar shading is used, d) reduced/increased U-values, etc. All results should be summarized in bar charts.

The solar heat load should be calculated for a representative/critical room (office) and for at least three alternative designs, e.g. a) different transmittance of the glazing, b) solar shading, c) orientation of the window/office.

4.0 Indoor environment in the office part. The predicted percentage dissatisfied (PPD) should be calculated for a representative/critical office room, normally at 1 m from the middle of the largest window, between 0.6 and 1.7 from the floor. The thermal comfort should be calculated in winter at DVUT and in summer for a critical summer day. The daylight factor (DF) should be calculated in the critical rooms, preferably on both floors.

5.0 Fire safety design. Define the occupancy class, fire compartments by qualitative analysis, and evacuation routes by calculations based on regulations and lecture on fire safety design.

6.0 Moisture performance of the building envelope. Identify critical locations for reference design by qualitative analysis. Present the results on drawings and descriptions. Each group member selects a critical detail for the quantitative analysis. Calculate the mould growth index (MGI) for the critical detail at the critical locations. Presents the results in graph of T, RH and MGI. Perform a 'probabilistic assessment' of the MGI for other working conditions or alternative designs, e.g. a) without vapour barrier, b) other S_d-value, c) without solar radiation, d) with a water leakage, etc. At least three different solutions should be regarded.



Miljöbyggnad and other certification systems

Certification issues that are covered by Miljöbyggnad in comparison to BREEAM, LEED and Green building are summarized below[2]. The issue 'Moisture prevention' has been recently tightened and today it is rather advanced in comparison to other certification methods.

COMPARISON BETWEEN ASSESSMENT METHODS	BREEAM Offices	LEED NC, CS	Miljö-byggnad	Green Building
Land Use	X	X		
Infrastructure/ communication	X	X		
Ecology	X	X		
Contaminants	X	X		
Energy	~35%	~35%	~30%	100%
Water	X	X		
Materials	X	X	X	
Waste	X	X		
Indoor Environmental Quality	X	X	X	
Construction phase	X	X	X	
Monitoring/follow-up	X	(X)	X	
LCC/LCA	X	(X)		
Acoustics	X		X	
Economy				
Social Factors				

WSP

[2] Therese Malm WSP, 2012.