BIM based iterative simulation - efficient building design: a case study

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Building facades (Revit 2018)

Room and space allocation (IDA-ICE 4.8)

Building design envelope

Roof		TEK-17	nZEB
Function	Materials	U-value: 0.13 W/m²K Thickness (mm)	U-value: 0.07 W/m²K Thickness (mm)
Finish (external)	roof tiles (11 tilt)	-	-
Membran layer	EPDM Membrane	20	20
Thermal/air layer	air in ltrating barrier	-	-
Structure	timber (90x315)	315	315
Insulation	mineral wool	260	500
Membran layer	vapor retarder	-	-
Finish (internal)	Gypsum	-	-
External walls		U-value: 0.18 W/m²K	U-value: 0.095 W/m²K
Function	Materials	Thickness (mm)	Thickness (mm)
Finish (external)	horizontal wood panels	-	-
Membran layer	EPDM Membrane	20	20
Thermal/air layer	air in ltrating barrier	-	-
Structure	timber (90x315)	315	315
Insulation	Mineral wool	175	350
Membran layer	vapor retarder	-	-
Finish (internal)	Gypsum	-	-
Floor		U-value: 0.09 W/m²K	U-value: 0.069 W/m²K
Function	Materials	Thickness (mm)	Thickness (mm)
Finish (oor)	wood ooring	-	-
Membran layer	vapor retarder	-	-
Insulation	mineral wool	350	500
Structure	concrete (24.1 mPa)	125	125
Thermal/air layer	damp pro ng	-	-
Membran layer	randon membrane	-	-
Substrate 1	Concrete (24.1 mPa)	300	300
Substrate 2	hardcore	100	100
Windows TEK-17	WWR 6.6% SHGC and ST	U-value	Internal/external emissivity
	0.15 and 0.1	0.6	0.837 (default)
Windows nZEB	WWR 6.6% SHGC and ST	U-value	Internal/external emissivity
	0.15 and 0.1	0.8	0.837 (default)
Insulation	Thermal conductivity	Density)	Speci c heat
Mineral wool	0.036 W/(mK)	20 kg/m³	750 J/(kg K)

Room and space data

Zones	People	Lightning*	Equipment*	Occupancy	Lightning	Equipment
Main area	2	100 W	3100 W	07-09 17-22	07-09 17-22	07-09 17-22
Bathroom	1	100 W	1750 W	Never present	Always o	07-09 17-22
Bedroom 1	1	40 W	50 W	21-07	Always o	21-07
Bedroom 2	1	40 W	50 W	21-07	Always o	21-07

Zones	Height	Heating	Cooling	Ventilation	ACH	Supply air
All zones	2.6m	21	25	AHU CAV	0.5	2 L/sm^2 height

*Effect (Watt) for equipment and lightning was obtained from [?]

Envelope transmission: Norwegian TEK-17 standard

Month	Walls	Roof	Floor	Windows	Doors	Thermal bridges
	🟧	🟥	🟦	🟦	🟪	🟩
1	-318.5	-174.9	-19.0	-232.7	-78.3	-126.7
2	-255.6	-147.2	-16.3	-194.1	-62.6	-105.2
3	-228.9	-146.6	-16.9	-190.9	-55.6	-102.8
4	-158.6	-116.6	-15.3	-148.8	-37.5	-79.5
5	-59.2	-80.0	-13.2	-95.2	-12.5	-48.1
6	-27.4	-63.5	-13.2	-74.0	-4.3	-36.8
7	-14.3	-55.9	-14.5	-63.1	-1.4	-30.3
8	-32.2	-57.0	-9.7	-67.5	-7.0	-33.1
9	-95.9	-78.0	-7.9	-96.1	-22.9	-45.4
10	-170.1	-106.8	-10.5	-137.2	-41.7	-72.6
11	-223.2	-126.0	-11.4	-164.8	-54.7	-88.7
12	-276.6	-151.2	-13.8	-200.6	-68.0	-108.6
Total	-1860.5	-1303.6	-161.7	-1665.0	-446.5	-881.9
During heating	-1723.3	-1145.2	-76.3	-1527.3	-421.9	-809.5
During cooling	-9.7	-23.5	-33.4	-17.0	1.2	-7.7
Rest of time	-127.5	-134.9	-52.0	-120.6	-25.8	-64.7
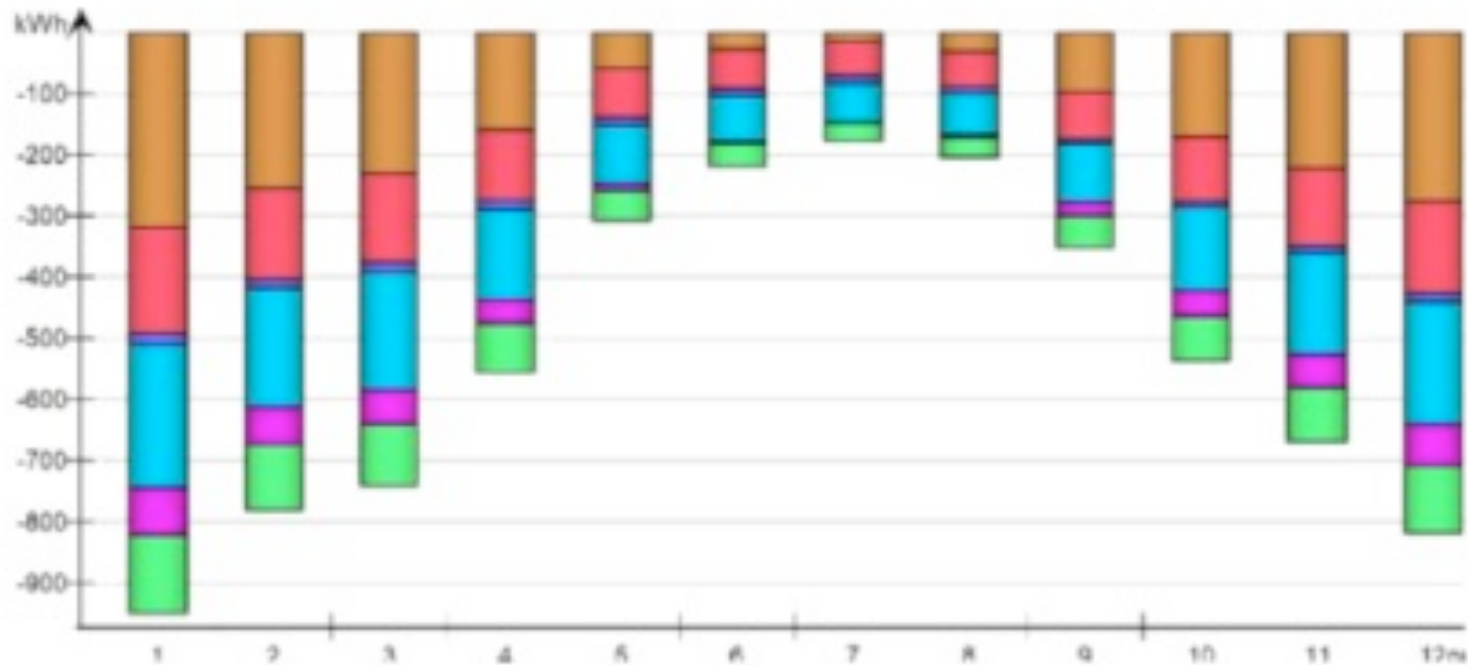
Energy use: Norwegian TEK-17 standard

		Purchased energy		Peak demand
		kWh	**kWh/m^2**	**kW**
🟨	Lighting, facility	308	5.3	0.17
🟩	Equipment, facility	1061	18.3	1.9
🟦	HVAC aux	272	4.7	0.19
🟧	Electric heating	3226	55.7	2.68
	Total, Facility electric	4867	84.1	
	Total	4867	84.1	
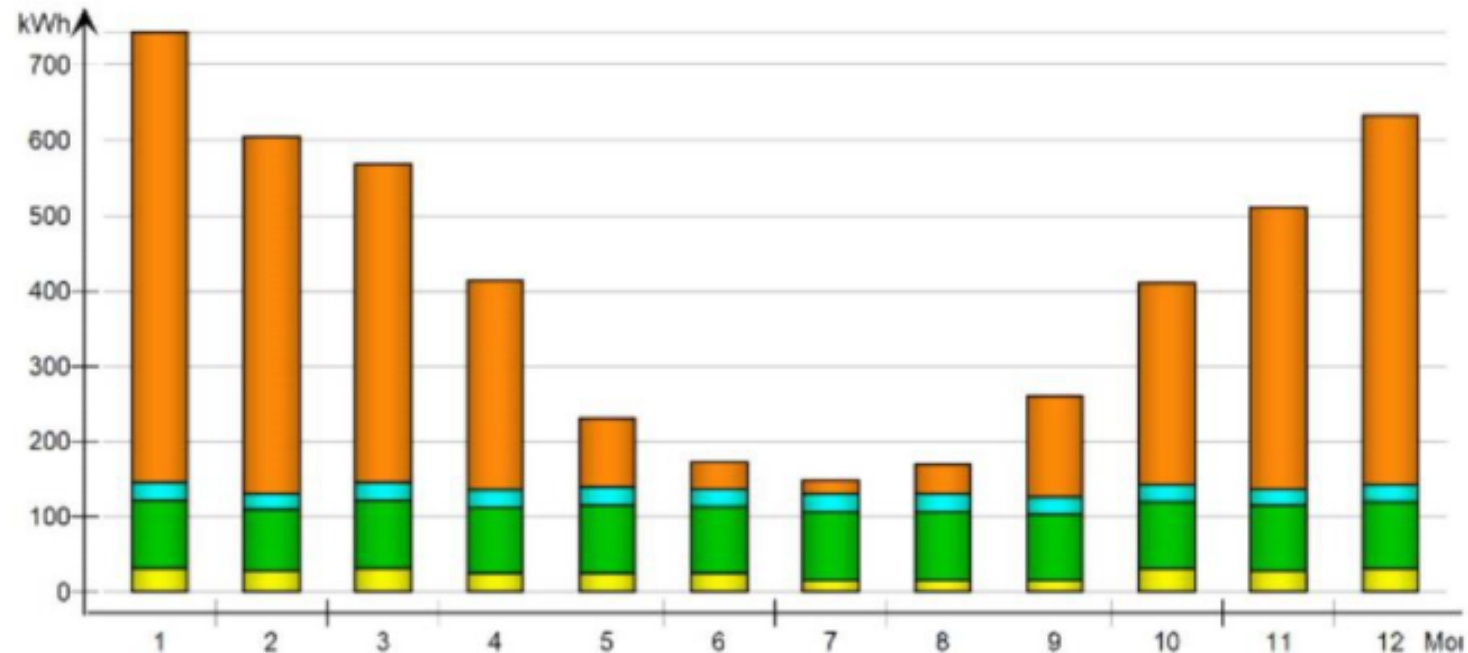
Envelope transmission: ZEB recommendations

Month	Walls	Roof	Floor	Windows	Doors	Thermal bridges
1	-204.2	-171.9	-8.9	-179.6	-80.2	-62.5
2	-164.2	-144.6	-9.3	-149.9	-63.9	-52.0
3	-147.0	-143.8	-11.4	-147.6	-56.4	-50.9
4	-102.8	-114.1	-11.9	-115.1	-37.5	-39.6
5	-40.5	-79.3	-14.0	-73.9	-12.2	-24.1
6	-21.0	-63.5	-14.4	-58.0	-4.2	-18.6
7	-12.8	-56.7	-15.7	-50.3	-1.7	-15.6
8	-22.7	-57.5	-10.5	-53.5	-7.1	-17.0
9	-62.6	-76.9	-7.7	-74.4	-22.6	-24.7
10	-108.6	-104.6	-6.9	-106.1	-41.8	-36.1
11	-143.0	-123.5	-6.9	-127.4	-55.2	-44.0
12	-177.5	-148.6	-7.8	-155.0	-69.2	-53.7
Total	-1206.9	-1285.0	-125.3	-1290.9	-451.9	-438.7
During heating	-1150.3	-1166.9	-42.8	-1197.5	-446.1	-409.4
During cooling	-8.4	-23.2	-26.9	-16.8	0.8	-4.7
Rest of time	-48.2	-94.9	-54.6	-76.6	-6.6	-24.6

Energy use: ZEB recommendations

		Purchased energy		Peak demand
		kWh	kWh/m^2	kW
■	Lighting, facility	308	5.3	0.17
■	Equipment, facility	1062	18.3	1.9
■	HVAC aux	272	4.7	0.19
■	Electric heating	2150	37.1	2.28
	Total, Facility electric	3792	65.5	
	Total	3792	65.5	
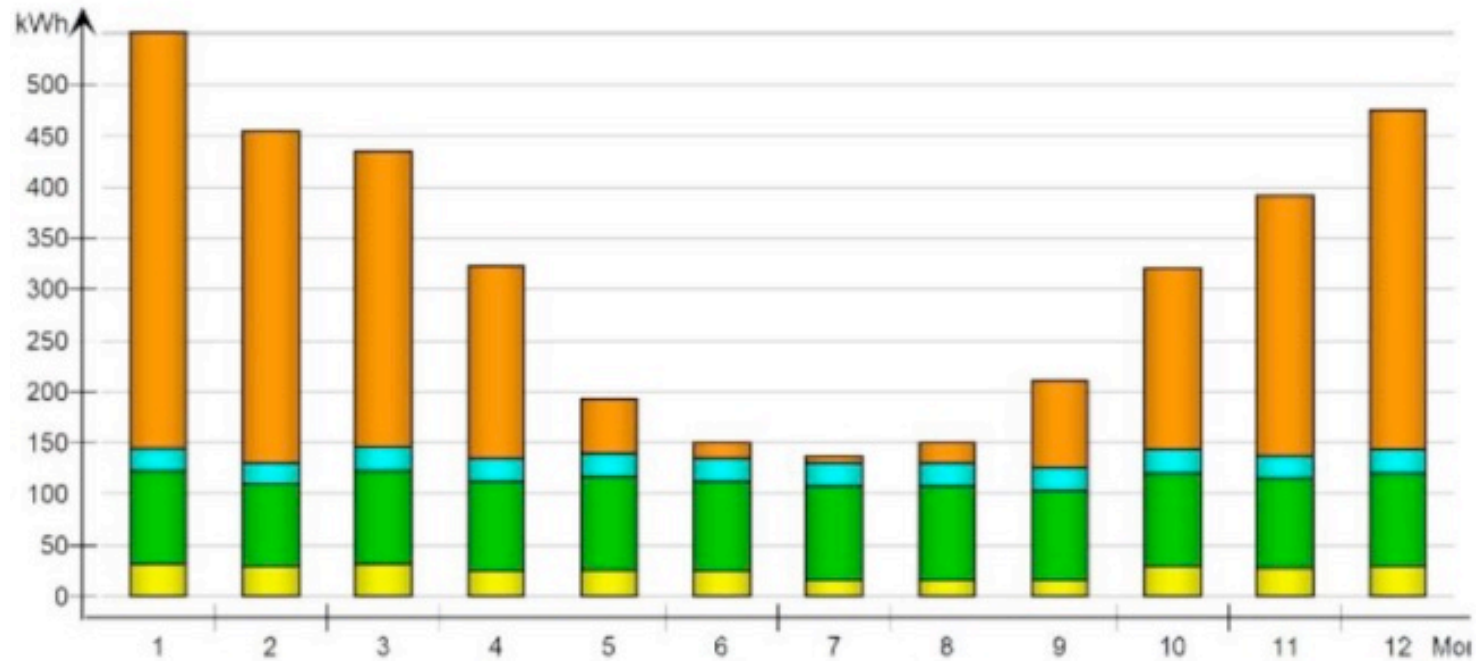
Design temperatures in main area (electric heating)
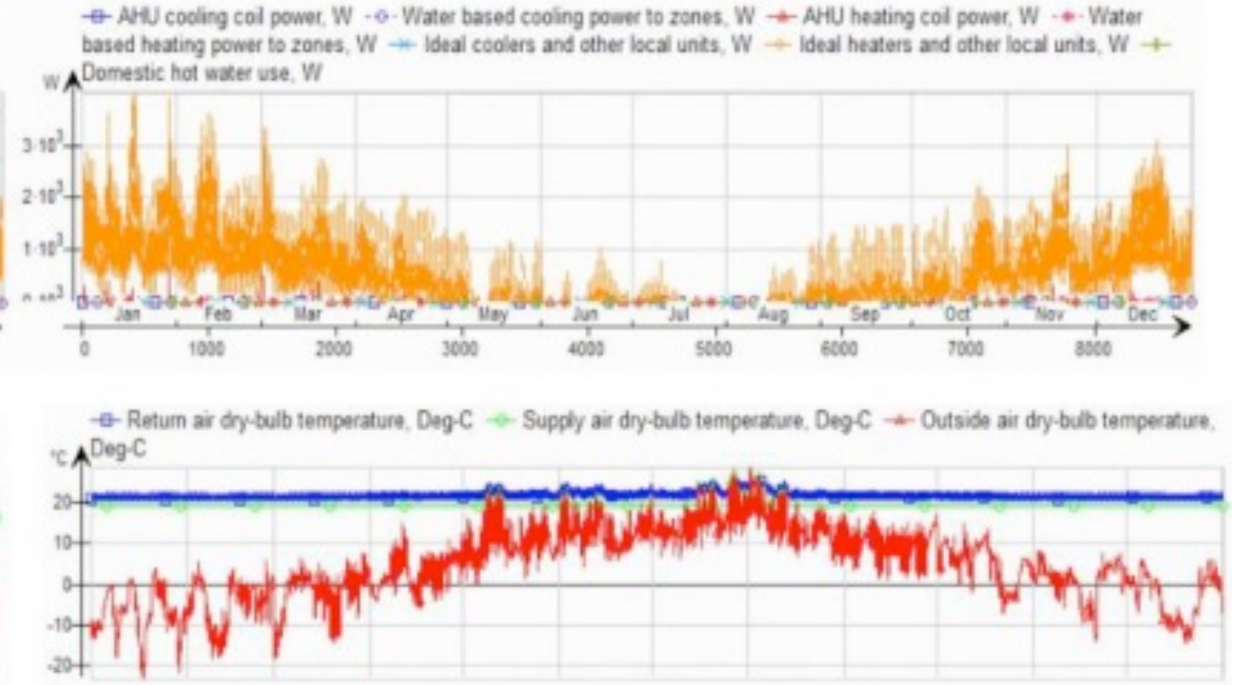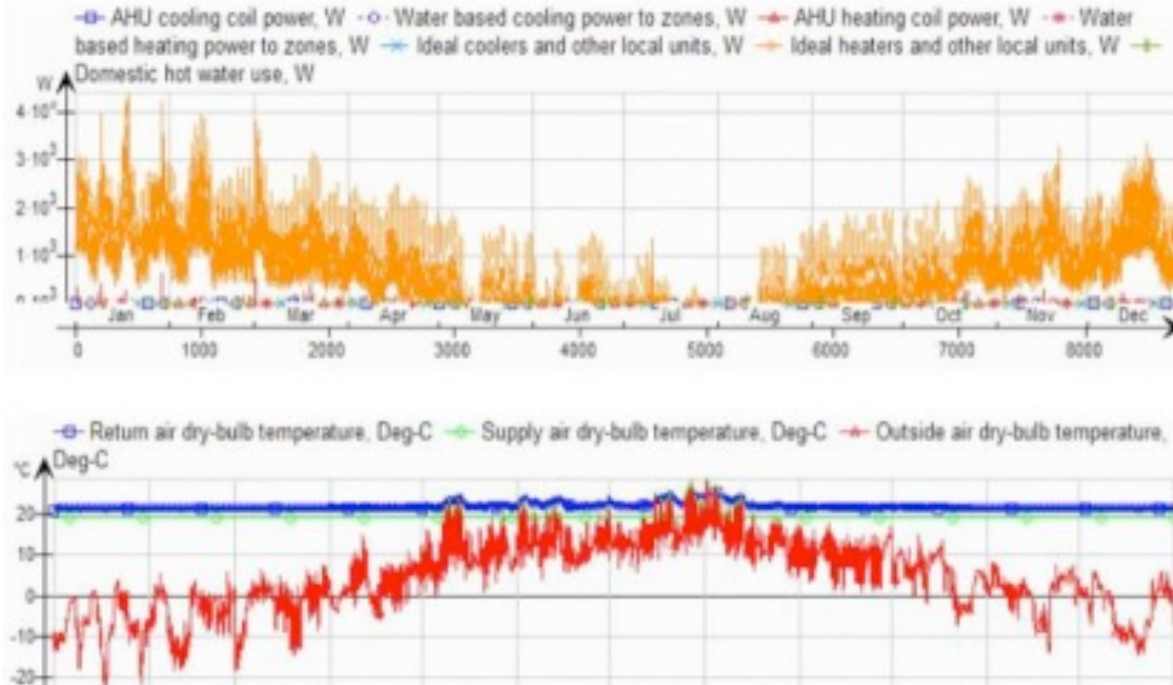
Break ven (PVGIS)

	PVGIS											
Efficiency	16%				18%				20%			
Escalation	1.30%	2.80%	4.30%	5.00%	1.30%	2.80%	4.30%	5.00%	1.30%	2.80%	4.30%	5.00%
Break even	26	22.8	20.2	19	24.6	21.2	19	18.2	22.9	20	17.9	17

Photo voltaic payback time (PVGIS)

Comclusion

- The design option with the lowest energy demand was found to be the optional concept building with electric floor heating and a air-to-air heat pump designed according to the ZEB specifcations.

  - By retrofitting the design from TEK-17 standard to nZEB, the energy demand reduction was found to be 22%.

- The cost of retrofitting was found to be neglect able, compared to the cost of energy efficient measures, like the photo voltaic system.

- Furthermore, experimental verification of the demonstrated energy demand potential is recommended.

Thank you.....

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