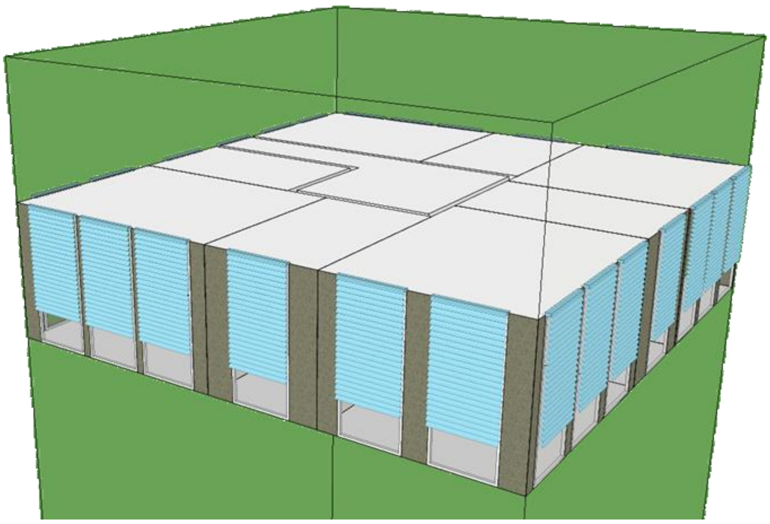
Full building simulation and case studies with FFG module for IDA ICE ready



This document represents a demonstrator in WP1:
Façade design & building simulation

Coordinator: Prof. Dr.-Ing. Dieter Brüggemann, University of Bayreuth, Germany
Tel: +49-(0)921-55-71 60, Fax: +49 (0) 921/55-71 65
Email: brueggemann@uni-bayreuth.de

European Commission
Horizon 2020
European Union funding
for Research & Innovation

After developing the simulation module for IDA ICE, it is implemented into the software. A full building simulation is carried out for a hot and a cold climate with three building types; office, residential and public in order to test the developed module. The results illustrate that the impact of FFG on energy use differs according to the building type for both hot and cold climates.

Content

1 Content of Deliverable

The content of deliverable is explained shortly in the proposal as following:

Full building simulation and case studies with FFG module for IDA ICE ready.

The performance of the software tool, which will be made available for early planning stage of FFG-containing ZEB, is tested for full building simulation and case studies for cold and hot climate in three different types of buildings.

2 Results and Discussion

According to the proposal hot and cold climates for three different building types should be analysed. The following climates and building types were choosen, which are more than required in the proposal;

- Cold climate; Sofia (Bulgaria)
- Hot climate; Madrid (Spain)
- Moderate climate; Frankfurt (Germany)
- Desert climate; Abu Dhabi (UAE) - Optional

Three building types were choosen; office, residential and public with 20 m² PV area. (the PV area is an assumption, it can be changed accordign to the project)

A sample floor plan is designed, which consists of nine zones (Figure 1 - Figure 4). The zones are oriented to four faces with FFG window modules. The dimension of each FFG module is 1.3x3.00 m. The zones have different floor areas. Each orientation has big and small zones, which can deliver the results for each orientation in order to compare them regarding FFG performance (outlet temperature and water heat gain).

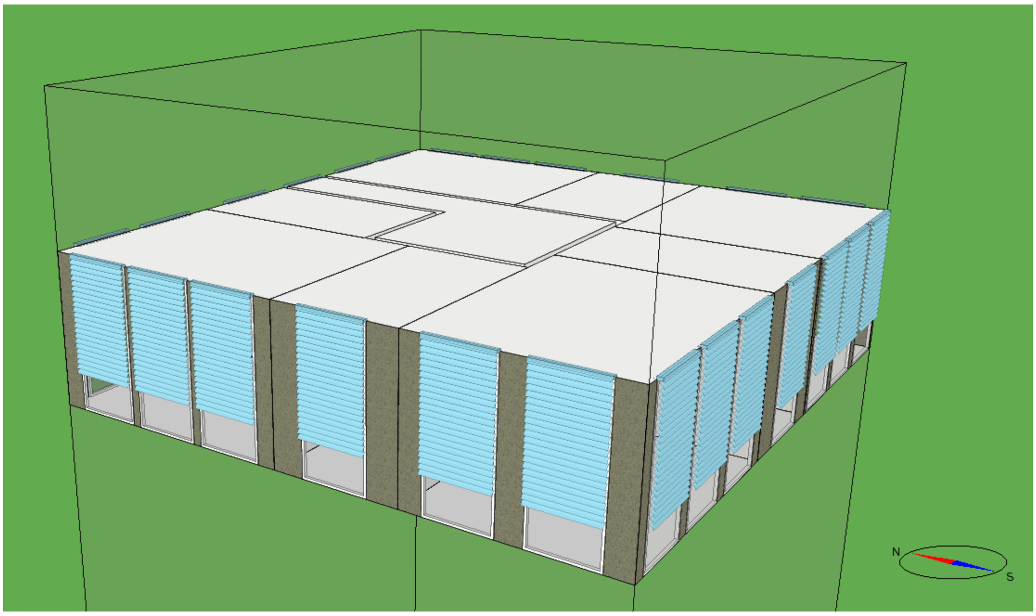


Figure 1: Perspective of Simulated floor

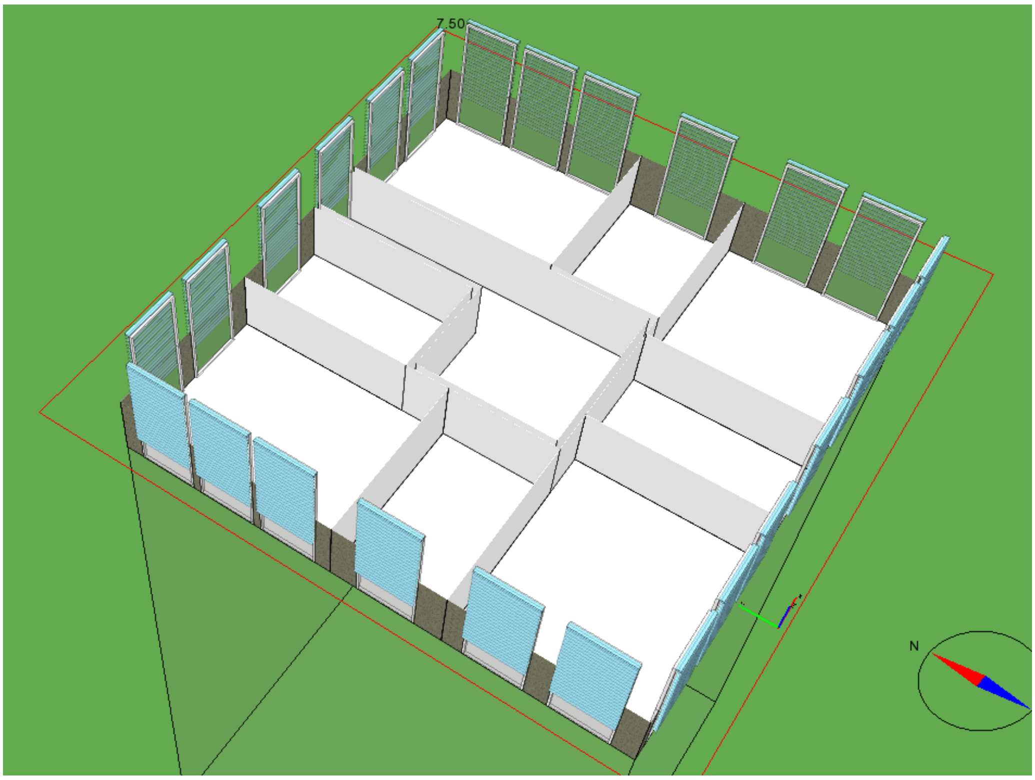


Figure 2: Perspective with zones overview

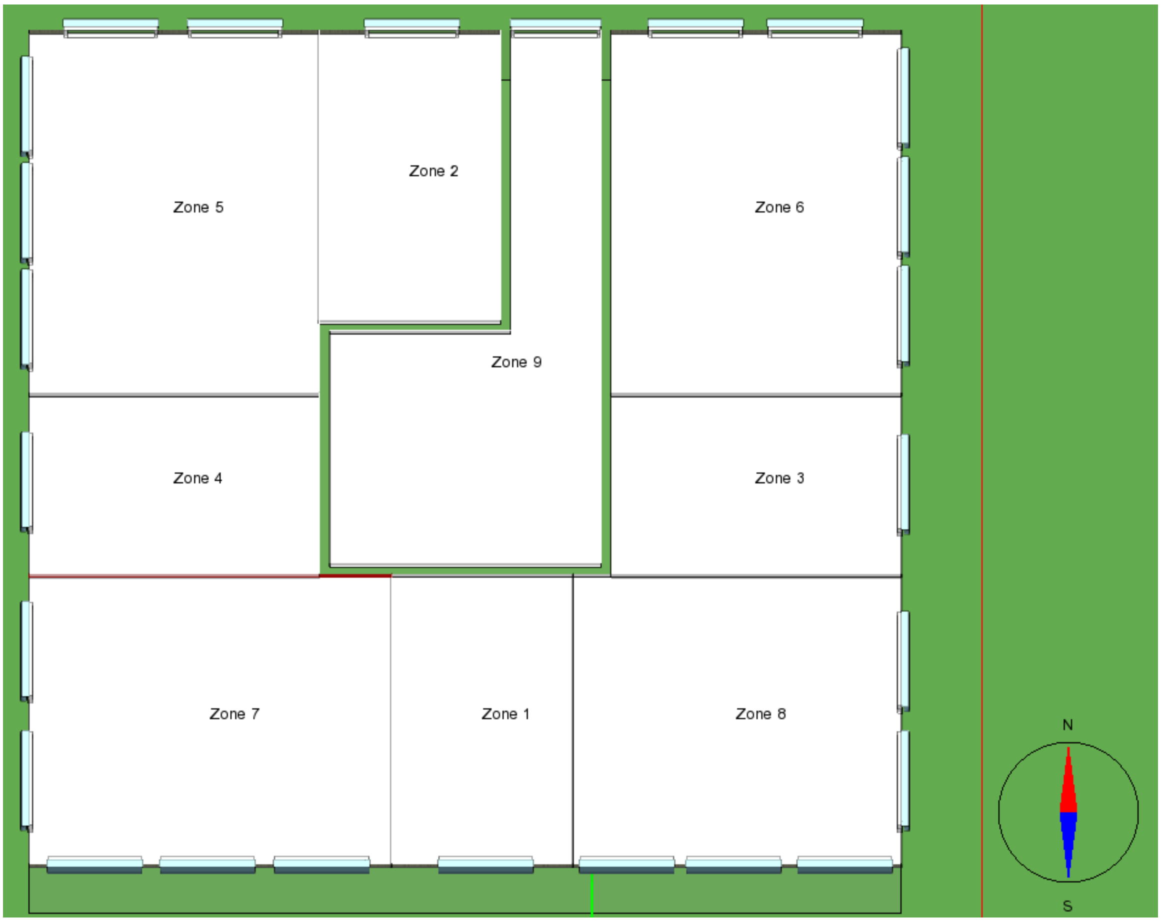


Figure 3: Simulated Zones

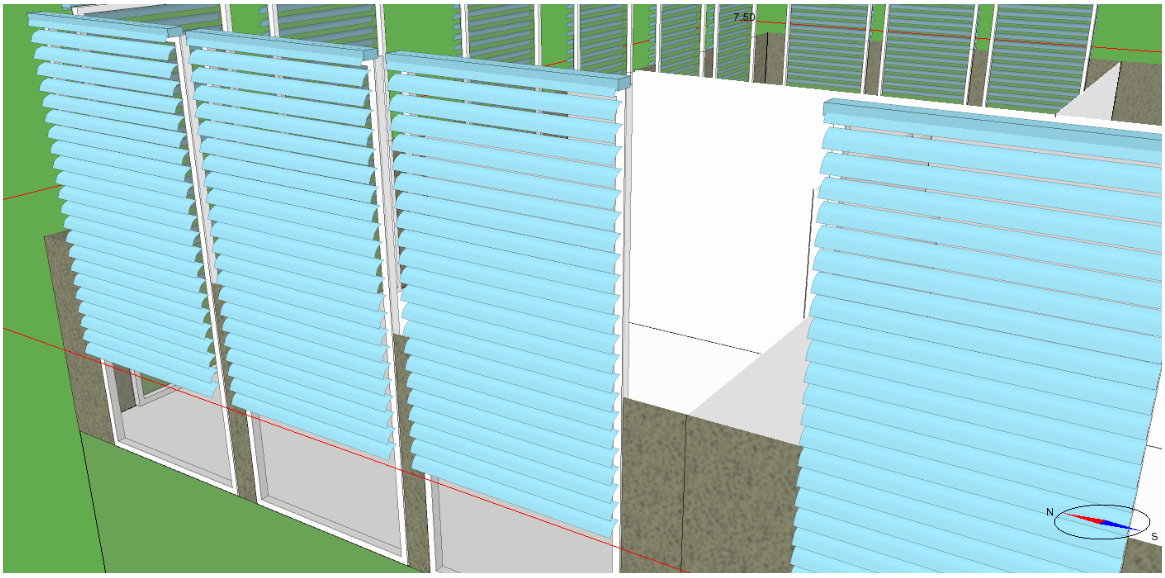


Figure 4: Shading element with Window module (Reference case)

The properties of building envelope, internal gains and HVAC system and their schedules are summarized in the following table:

Table 1: Boundary conditions for the simulations

Input Parameters	**Units**	**Office**	**Residential**	Public (School)
Net Floor Area	m2	m2	m2	m2
Working time	Mo-Fri	9:00-18:00	00:00-24:00	8:00-15:00
Heating temperature set point	ºC	21,00	21,00	21,00
Cooling temperature Set Point	ºC	25,00	25,00	25,00
Never under	ºC	16,00	18,00 (0-8)	16,00
Never over	ºC	28,00	28,00 (0-8)	28,00
Minimum fresh air	m^3/h person	30,00	15,00	30,00
Infiltration	ACH (n50)	0,03	0,03	0,03
Heat recovery	85,00%	yes	yes	yes
Internal Gains				
Occupation	man/m2	0,10	According to the DIN 18599, total internal gains 3,75 W/m²	0,45
Computers	W/m2	5,50		0,00
Office equipment	W/m2	2,00		4,00
Lighting	lx	500,00		300,00
	W/m2 per 100 lx	1,60		1,60
Total light	W/m²	8,00		4,80
Building Envelope				
U wall	W/m2*K	0,17	0,17	0,17
U roof	W/m2*K	0,12	0,12	0,12
U ground floor	W/m2*K	0,27	0,27	0,27
U window	W/m2*K	1,313	1,313	1,313
G-Value	-	0,265	0,265	0,265
Light transmission	-	0,355	0,355	0,355
Input parameters	**Units**	**Office**	**Residential**	Public (School)
U window	W/m2*K	0,956	0,956	0,956
G-Value	-	0,245	0,245	0,245
Light transmission	-	0,514	0,514	0,514

For the first Simulation studies, an inlet temperature of 17 °C with a very low flow rate of 0,033 kg/s is used (0,5 lt/min.m²). In the second study phase the flow rate is increased to 0,13 kg/s (which is calculated with 2 lt/min.m² and window area of 3,9 m²). Each window element represents a FFG module.

Short results discussion:

As seen in the following Table 2 and Table 3, the system energy demand of four different climate regions and three building types. Three building types differs according to their internal gains. The window façade ratio was kept similar for those three building types in order to accelerate the simulation time. Table 2 and Table 3 illustrate that each building type should have another WFG strategy due to the differences in occupancy time and internal gains. For example the inlet temperatures and flow rate can be altered according to the heating and cooling need of the room. Some of the higher heating loads of Sofia, Frankfurt and Madrid are caused by low inlet temperatures of 17 °C and schedule of the building use. Additionally, a city in a very hot climate , Abu Dhabi, is choosen in order to study the influence of the FFG elements in such an extreme climate. It can be clearly seen that the cooling loads are still high, inspite of FFG elements. The reasons for the high cooling loads in Abu Dhabi may be reduced by using different façade design, for example; more opaque elements in order to reduce solar heat gain through the window. Sofia and Franfkurt have highest heating demand.

Table 2: Results of the system energy for each climate and building type

	Sofia		Madrid		Frankfurt		Abu-Dhabi	
Simulation Cases	COOLING (kWh)	HEATING (kWh)	COOLING (kWh)	HEATING (kWh)	COOLING (kWh)	HEATING (kWh)	COOLING (kWh)	HEATING (kWh)
Office	2597	3433	3639	1604	2151	3759	15150	0
Residential	2472	7285	3352	4099	2011	7710	16133	413
Public	2861	2849	4270	1307	2425	3043	17547	485

Table 3: Specific results of system energy for each climate and building type

	Sofia		Madrid		Frankfurt		Abu-Dhabi	
Simulation Cases	COOLING (kWh/m²a)	HEATING (kWh/m²a)	COOLING (kWh/m²a)	HEATING (kWh/m²a)	COOLING (kWh/m²a)	HEATING (kWh/m²a)	COOLING (kWh/m²a)	HEATING (kWh/m²a)
Office	22,0	29,1	30,8	13,6	18,2	31,8	128,3	0,0
Residential	20,9	61,7	28,4	34,7	17,0	65,3	136,6	3,5
Public	24,2	24,1	36,1	11,1	20,5	25,8	148,6	4,1

Other results can be seen in the annex.

Until end of the project, different flow rates and inlet temperatures according to the schedule can be applied in order to find optimal flow rate and inlet temperatures for different climates and building types.

3 Degree of Progress

This Deliverable is postponed due to the updated FFG and radiant internal wall (RIW) modules for IDA ICE and adequate monitoring data derived from Spanish Mock-up.

4 Dissemination

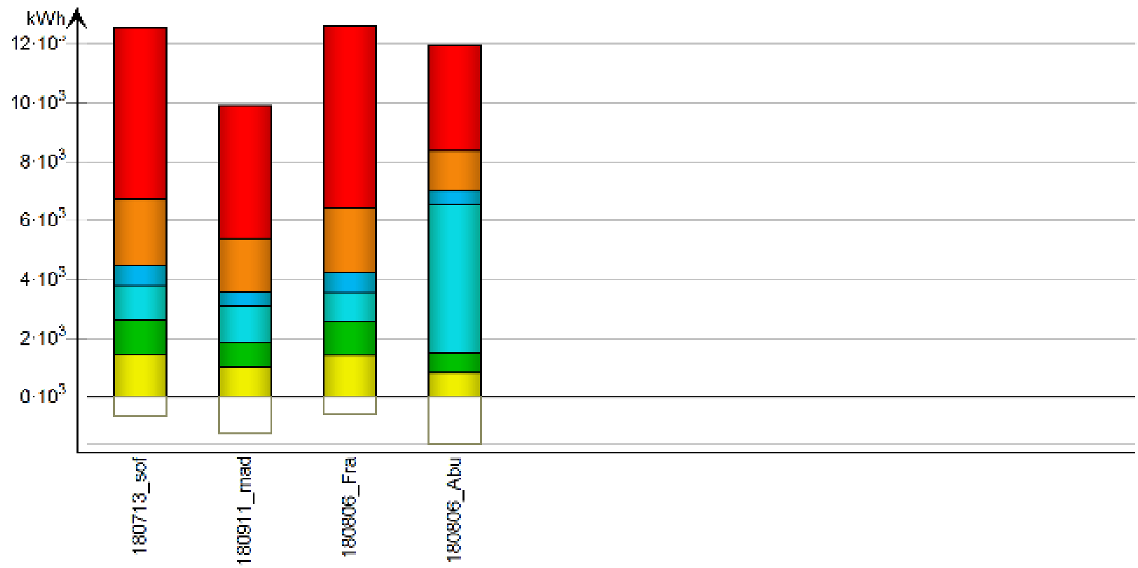
The document is available on the InDeWaG website.

5 Annexe

Supplied Energy

Meter Energy

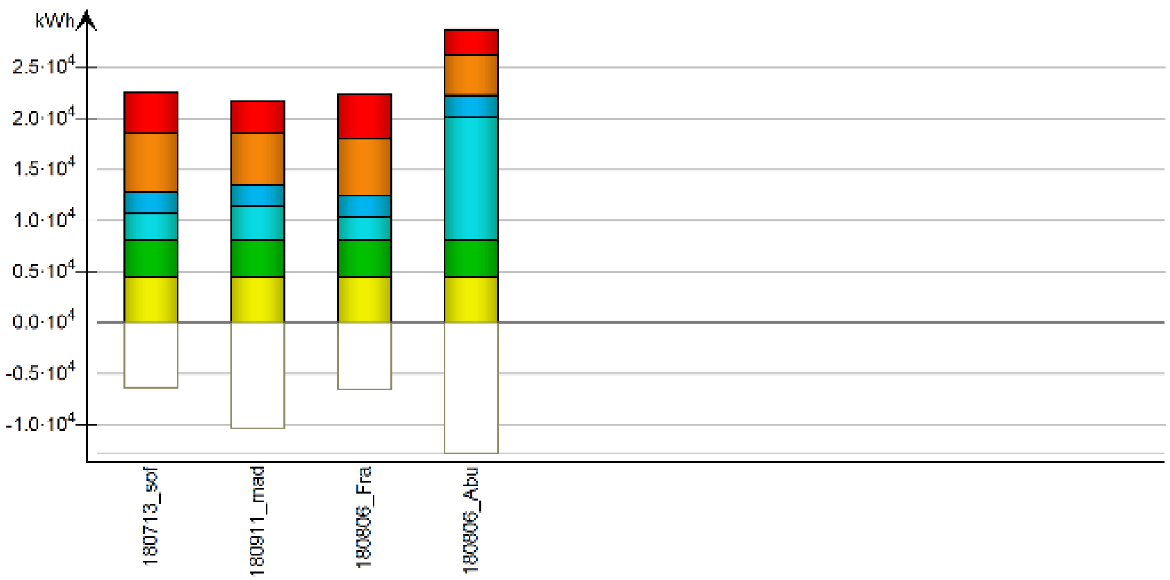
	180713_sof		180911_mad		180806_Fra		180806_Abu	
	kWh	kWh/m²	kWh	kWh/m²	kWh	kWh/m²	kWh	kWh/m²
Lighting, facility	1455	10.8	1033	7.6	1426	10.5	828	6.1
Equipment, facility	1191	8.8	846	6.3	1168	8.6	678	5.0
Electric cooling	1157	8.6	1255	9.3	978	7.2	5047	37.3
Fans	692	5.1	484	3.6	675	5.0	451	3.3
Pumps	13	0.1	11	0.1	11	0.1	48	0.4
Electric heating	2238	16.6	1797	13.3	2206	16.3	1330	9.8
Total, Facility electric	6746	49.9	5426	40.1	6464	47.8	8382	62.0
District heating	5818	43.0	4516	33.4	6171	45.6	3591	26.6
Total, Facility district	5818	43.0	4516	33.4	6171	45.6	3591	26.6
Total	12564	92.9	9942	73.5	12635	93.4	11973	88.5
PV production	-611	-4.5	-1226	-9.1	-595	-4.4	-1575	-11.7
CHP production	0	0.0	0	0.0	0	0.0	0	0.0
Total, Produced electric	-611	-4.5	-1226	-9.1	-595	-4.4	-1575	-11.7
Grand total	11953	88.4	8716	64.5	12040	89.0	10398	76.9



A1: Comparison of four-climate regions- Supplied energy

Primary Energy

	180713_sof		180911_mad		180806_Fra		180806_Abu	
	kWh	kWh/m²	kWh	kWh/m²	kWh	kWh/m²	kWh	kWh/m²
Lighting, facility	4498	33.3	4499	33.3	4499	33.3	4496	33.2
Equipment, facility	3683	27.2	3684	27.2	3684	27.2	3681	27.2
Electric cooling	2664	19.7	3398	25.1	2349	17.4	12009	88.8
Fans	2084	15.4	2093	15.5	2083	15.4	2119	15.7
Pumps	38	0.3	41	0.3	34	0.3	151	1.1
Electric heating	5677	42.0	5004	37.0	5592	41.4	3937	29.1
Total, Facility electric	18644	137.9	18719	138.4	18241	134.9	26393	195.2
District heating	4073	30.1	3161	23.4	4320	31.9	2513	18.6
Total, Facility district	4073	30.1	3161	23.4	4320	31.9	2513	18.6
Total	22717	168.0	21880	161.8	22561	166.8	28906	213.7
PV production	-6374	-47.1	-10320	-76.3	-6502	-48.1	-12783	-94.5
CHP production	0	0.0	0	0.0	0	0.0	0	0.0
Total, Produced electric	-6374	-47.1	-10320	-76.3	-6502	-48.1	-12783	-94.5
Grand total	16343	120.8	11560	85.5	16059	118.7	16123	119.2



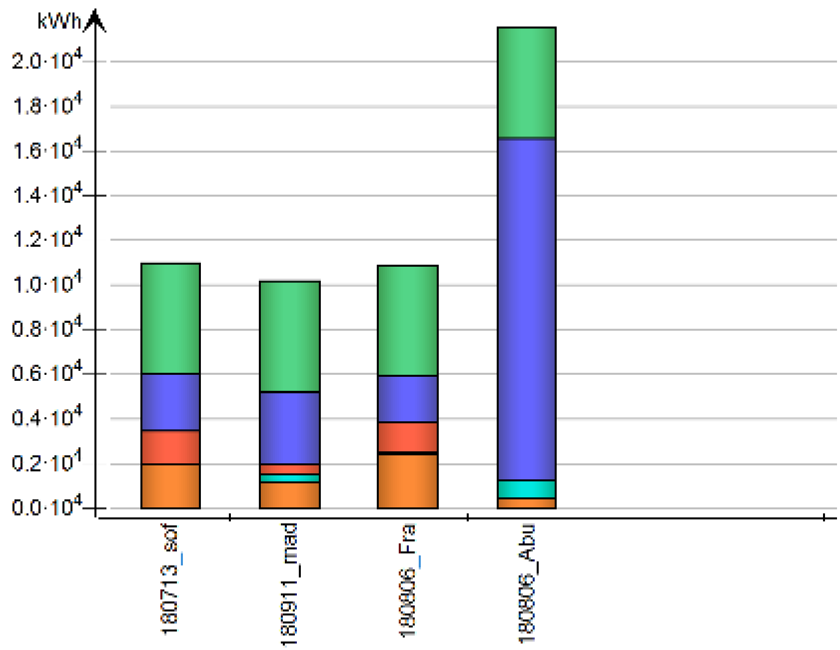
A2: Comparison of four-climate regions- Primary energy

Systems Energy

Used energy

kWh

Case	Zone heating	Zone cooling	AHU heating	AHU cooling	Dom. hot water
180713_sof	1972.1	31.1	1461.0	2566.0	4943.8
180911_mad	1199.8	371.8	405.3	3267.2	4943.8
180806_Fra	2409.4	114.8	1350.0	2037.1	4943.8
180806_Abu	413.5	834.1	0.1	15299.5	4943.8

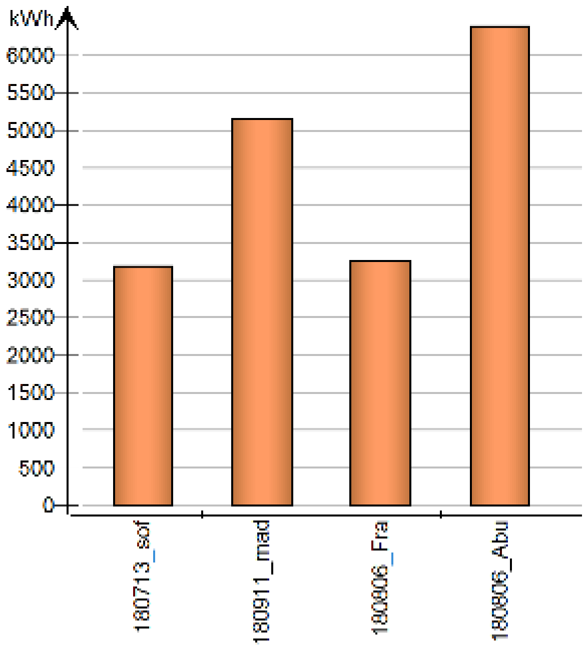


A3: Comparison of four-climate regions- Used energy

Generated electric energy

kWh

Case	Solar (PV)	Wind turbine	CHP
180713_sof	3186.9		
180911_mad	5159.9		
180806_Fra	3251.2		
180806_Abu	6391.5		

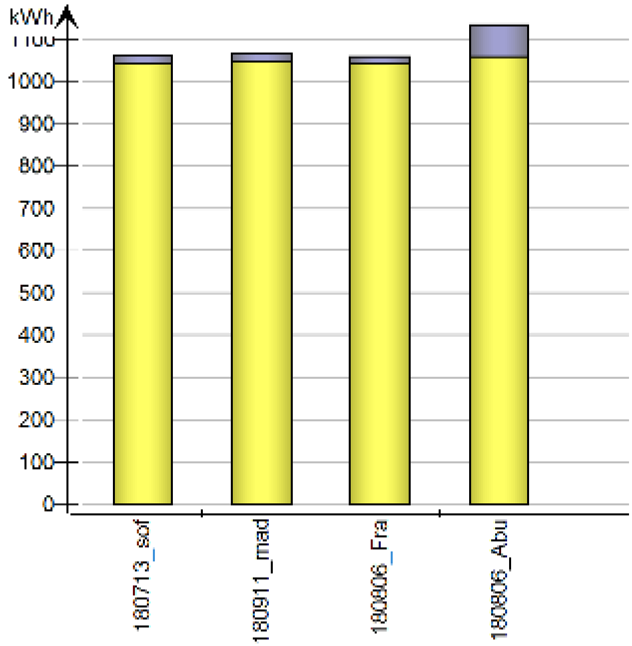


A4: Comparison of four-climate regions- Generated electric energy

Auxiliary energy

kWh

Case	Humidi-fication	Fans	Pumps
180713_sof		1041.8	18.9
180911_mad		1046.4	20.6
180806_Fra		1041.5	16.8
180806_Abu		1059.3	75.3



A5: Comparison of four-climate regions- Auxiliary energy