ENERGY AND ENVIRONMENTAL TECHNOLOGIES FOR BUILDING SYSTEMS

SKETCHUP&OPENSTUDIO REPORT

Project by

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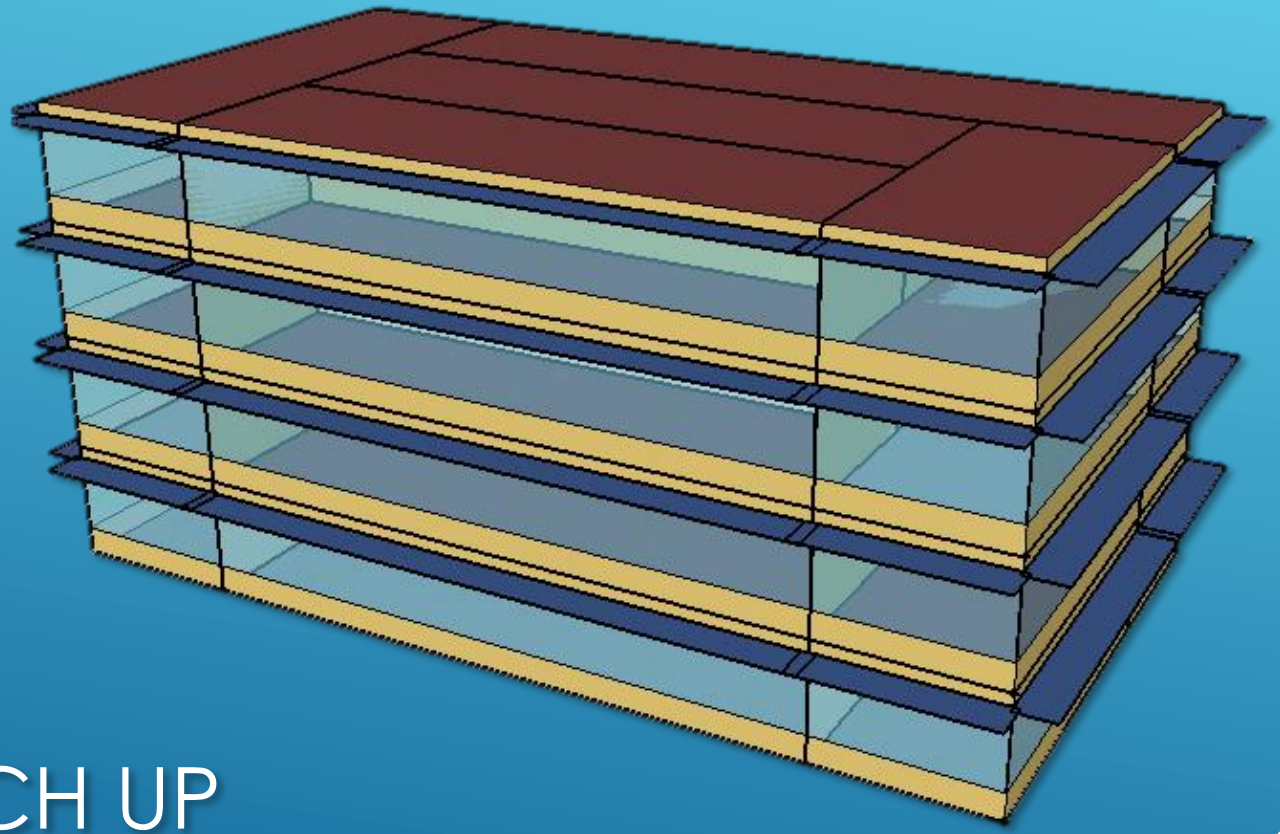
INTRODUCTION

- We started building the *geometry* of a commercial building in **SketchUp**
- Using **OpenStudio** we defined the other characteristics of the building such as *schedule* sets, *definitions* (light, people…)
- We then calculated the yearly heating and cooling *consumption* of the building for a **base case**
- We investigated the effects of changing the *location*, *wall* characteristics, and *window* type on energy consumption
- A total of three different cities and three different walls/windows have been **compared** with the corresponding base case.

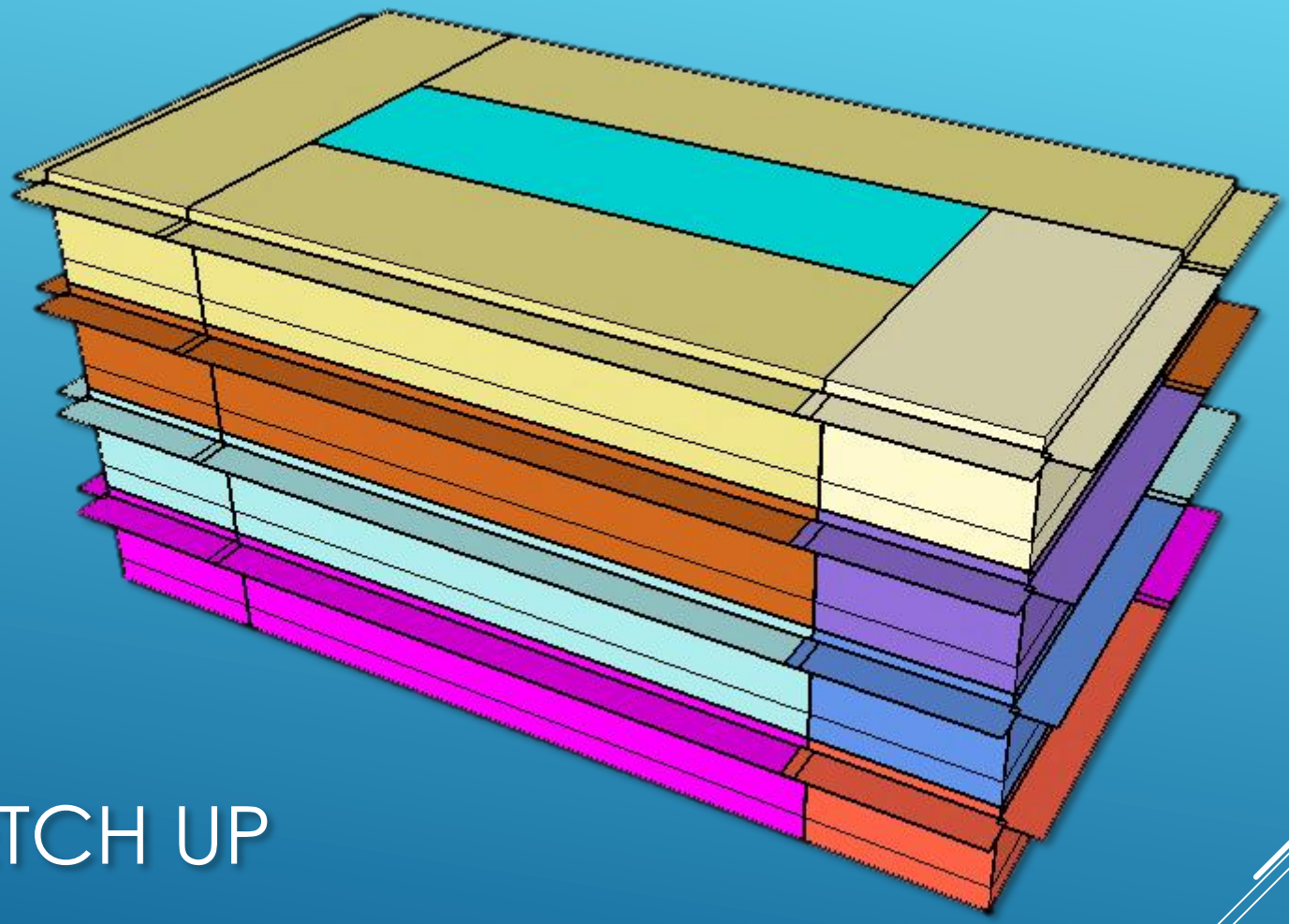
The building



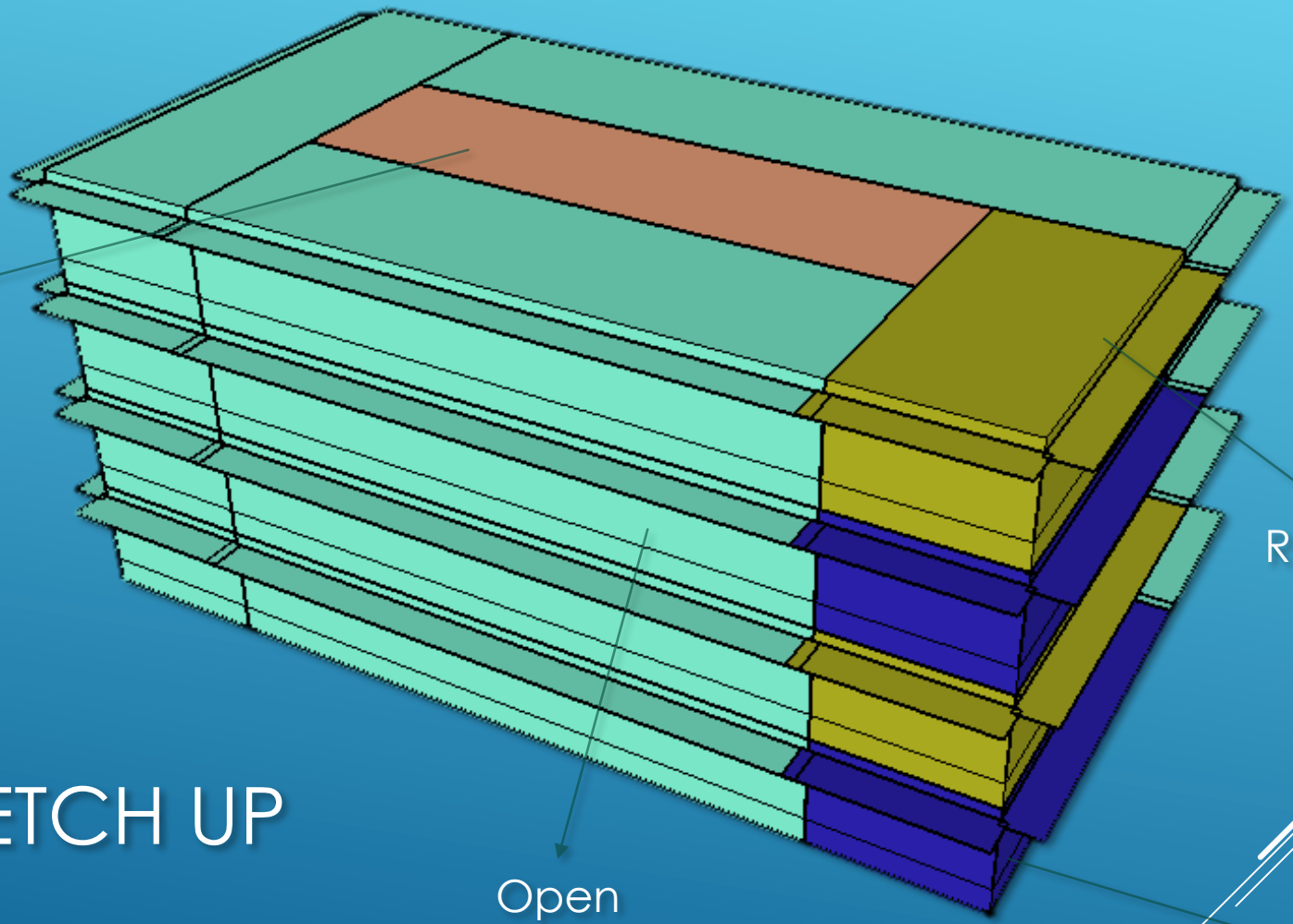
SKETCH UP

SKETCH UP

Thermal Zones



Space Types



SKETCH UP

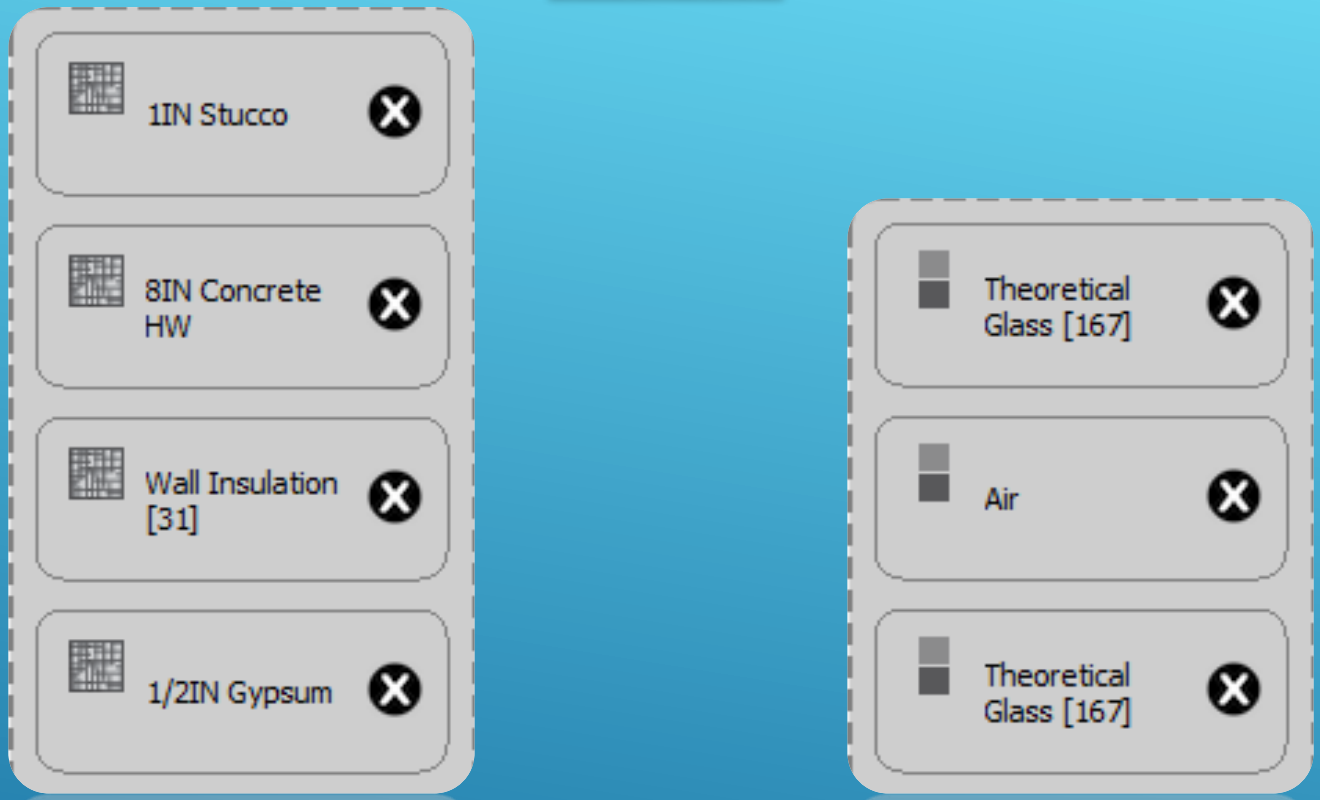
BASE, WORST, BETTER, BEST CASES

We defined different cases according to different construction sets:

- Base: default OpenStudio sets
- Worst: worse building characteristics compared to base case
- Better: slight improvements to the base case
- Best: extreme improvements to the base case

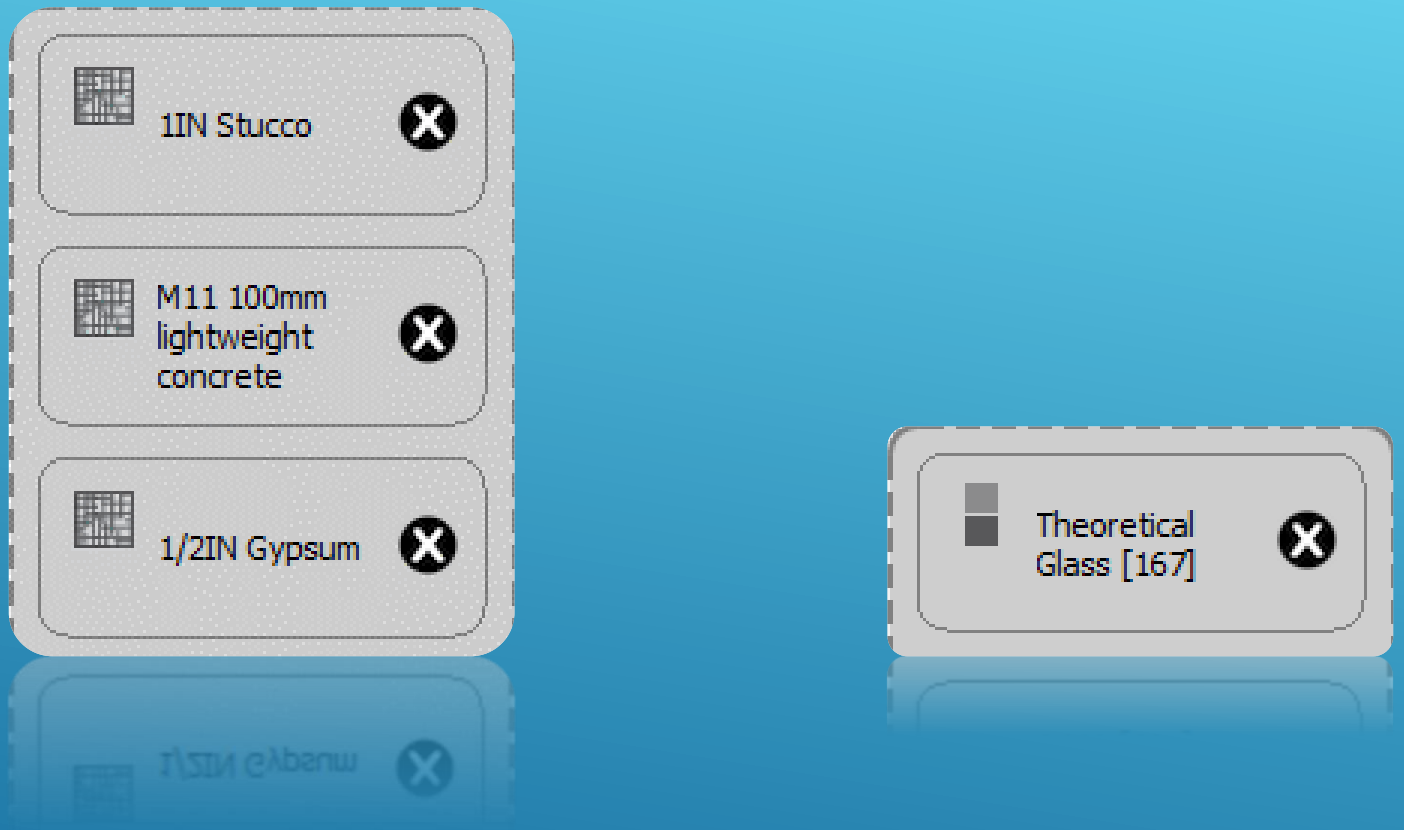
All cases have the same schedule sets and definitions.

Base case



CONSTRUCTION SETS

Worst case



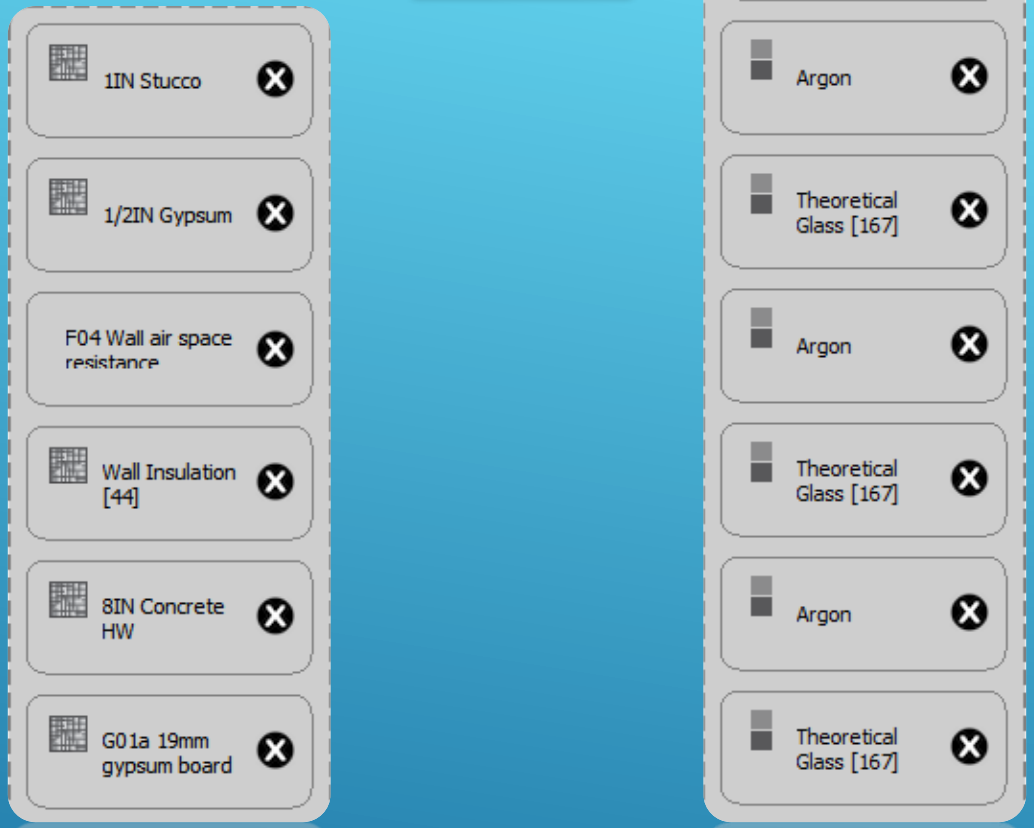
CONSTRUCTION SETS

CONSTRUCTION SETS

Better case

CONSTRUCTION SETS

Best case



WEATHER DATA

FIRENZE/PERETOLA, Italy — WMO#: 161700

Lat: 43.80N Long: 11.20E Elev: 38 StdP: 100.87 Time Zone: 1.00 (EUW) Period: 95-10 WBAN: 99999

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS	PCWD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
(1) 1	-3.1	-1.2	-10.6	1.5	3.2	-8.4	1.9	2.9	10.4	5.2	8.4	5.9	0.8	80

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(2) 7	12.2	35.1	22.2	33.8	22.0	32.1	21.4	24.3	31.4	23.5	30.3	22.7	29.4	3.7	250

Dehumidification DP/MCDB and HR 0.4% DP	0.4% HR	0.4% MCDB	1% DP	1% HR	1% MCDB	2% DP	2% HR	2% MCDB	Enthalpy/MCDB 0.4% Enth	0.4% MCDB	1% Enth	1% MCDB	2% Enth	2% MCDB	Hours 8 to 4 & 12.8/20.6
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
22.2	17.0	27.0	21.2	15.9	26.6	20.3	15.0	26.2	73.4	31.1	70.0	30.4	67.1	29.1	977

KOEBENHAVN/KASTRUP, Denmark — WMO#: 061800

Lat: 55.62N Long: 12.65E Elev: 5 StdP: 101.26 Time Zone: 1.00 (EUW) Period: 86-10 WBAN: 99999

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS	PCWD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
(1) 2	-7.9	-6.0	-11.2	1.4	-5.7	-9.4	1.7	-4.3	14.9	4.8	13.5	3.8	4.6	60

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(2) 7	7.8	25.5	18.1	24.0	17.5	22.4	16.8	19.5	23.2	18.6	22.2	17.7	21.2	4.6	160

Dehumidification DP/MCDB and HR 0.4% DP	0.4% HR	0.4% MCDB	1% DP	1% HR	1% MCDB	2% DP	2% HR	2% MCDB	Enthalpy/MCDB 0.4% Enth	0.4% MCDB	1% Enth	1% MCDB	2% Enth	2% MCDB	Hours 8 to 4 & 12.8/20.6
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
18.2	13.1	21.0	17.2	12.3	20.1	16.2	11.5	19.4	55.7	23.0	52.6	22.1	50.1	21.4	1045

MALAGA/AEROPUERTO, Spain — WMO#: 084820

Lat: 36.67N Long: 4.48W Elev: 7 StdP: 101.24 Time Zone: 1.00 (EUW) Period: 86-10 WBAN: 99999

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6% DP	99.6% HR	99.6% MCDB	99% DP	99% HR	99% MCDB	0.4% WS	0.4% MCDB	1% WS	1% MCDB	MCWS	PCWD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
(1) 1	4.0	5.3	-4.1	2.7	11.1	-1.8	3.3	11.5	13.5	12.7	12.1	13.4	4.3	300

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB 0.4% DB	0.4% MCWB	1% DB	1% MCWB	2% DB	2% MCWB	Evaporation WB/MCDB 0.4% WB	0.4% MCDB	1% WB	1% MCDB	2% WB	2% MCDB	MCWS/PCWD to 0.4% DB MCWS	PCWD
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(2) 8	9.4	35.0	20.3	32.9	20.2	30.9	20.0	24.0	28.1	23.4	27.5	22.8	27.0	5.0	180

Dehumidification DP/MCDB and HR 0.4% DP	0.4% HR	0.4% MCDB	1% DP	1% HR	1% MCDB	2% DP	2% HR	2% MCDB	Enthalpy/MCDB 0.4% Enth	0.4% MCDB	1% Enth	1% MCDB	2% Enth	2% MCDB	Hours 8 to 4 & 12.8/20.6
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
22.8	17.6	26.3	22.0	16.7	26.1	21.2	15.9	25.6	71.8	28.2	69.6	27.4	67.4	27.1	1355

Base

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	279.23	0.00
Cooling	0.00	0.00	0.00	292.08	0.00	0.00

Worst

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	391.80	0.00
Cooling	0.00	0.00	0.00	320.04	0.00	0.00

Better

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	228.90	0.00
Cooling	0.00	0.00	0.00	289.57	0.00	0.00

Best

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	194.24	0.00
Cooling	0.00	0.00	0.00	289.30	0.00	0.00

FIRENZE

Base

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	608.27	0.00
Cooling	0.00	0.00	0.00	82.98	0.00	0.00

Worst

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	901.17	0.00
Cooling	0.00	0.00	0.00	81.00	0.00	0.00

Better

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	485.62	0.00
Cooling	0.00	0.00	0.00	89.90	0.00	0.00

Best

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	405.89	0.00
Cooling	0.00	0.00	0.00	96.26	0.00	0.00

COPENHAGEN

MALAGA

Base

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	90.80	0.00
Cooling	0.00	0.00	0.00	358.49	0.00	0.00

Worst

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	137.12	0.00
Cooling	0.00	0.00	0.00	400.13	0.00	0.00

Better

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	72.08	0.00
Cooling	0.00	0.00	0.00	355.07	0.00	0.00

Best

	Electricity [GJ]	Natural Gas [GJ]	Additional Fuel [GJ]	District Cooling [GJ]	District Heating [GJ]	Water [m3]
Heating	0.00	0.00	0.00	0.00	57.94	0.00
Cooling	0.00	0.00	0.00	356.35	0.00	0.00

CONCLUSIONS

Energy consumption is noticeably reduced in the better case, where relatively small improvements are applied to the base case.

The best case, instead, doesn't considerably improve the situation, with respect to the better case, specially for cooling load (which for Copenhagen gets even worse because of the highly reduced heat transmission through surfaces).

We therefore suggest to apply modifications as illustrated in the better case in order to have a significant energy saving but restrained expenses on construction costs.