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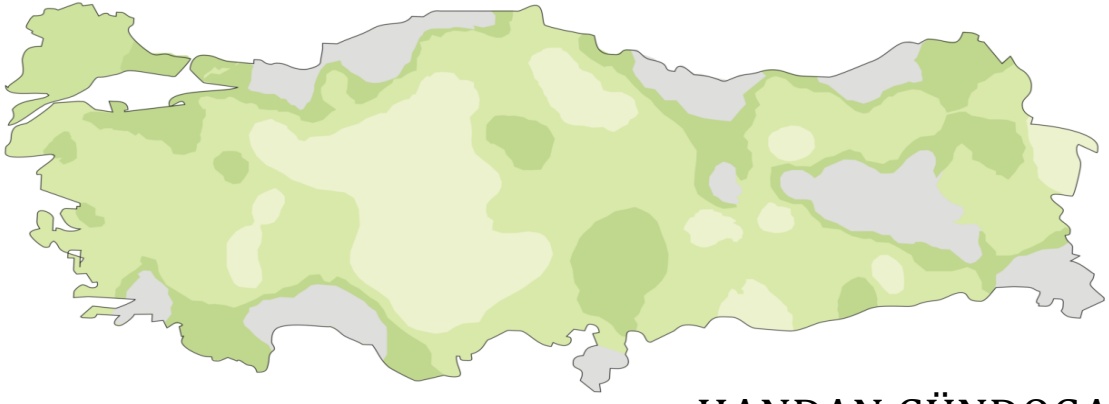
LIFE CYCLE COSTING OF SUSTAINABLE STRATEGIES

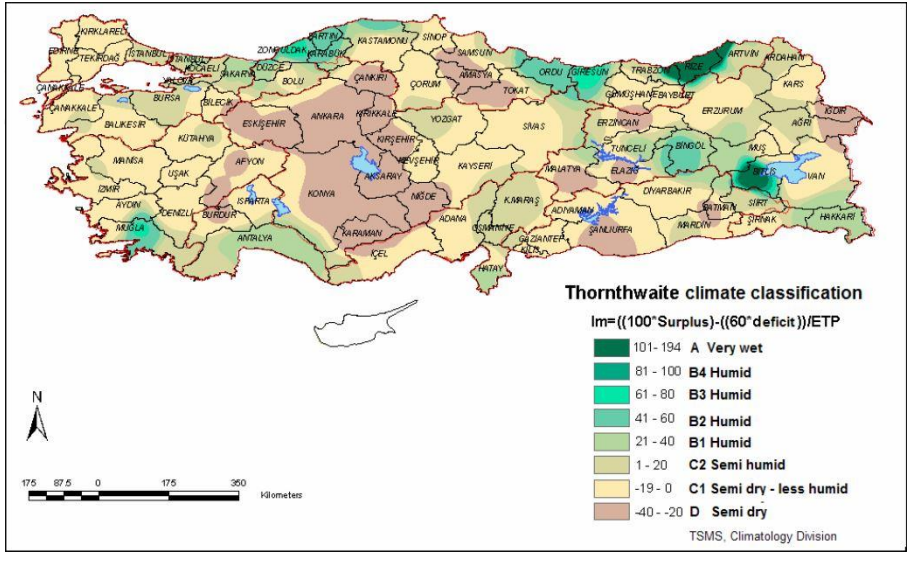
3 climate zones of Turkey



HANDAN GÜNDOGAN, Civil Engineer

1st August 2014

Transsolar Mentor: Monika Schultz


Thornthwaite climate classification
Im=((100*Surplus)-((60*deficit))/ETP
101- 194 A Very wet
81 - 100 B4 Humid
61 - 80 B3 Humid
41 - 60 B2 Humid
21 - 40 B1 Humid
1 - 20 C2 Semi humid
-19 - 0 C1 Semi dry - less humid
-40 - -20 D Semi dry
TSMS, Climatology Division
N
175 87.5 0 175 350
Kilometers

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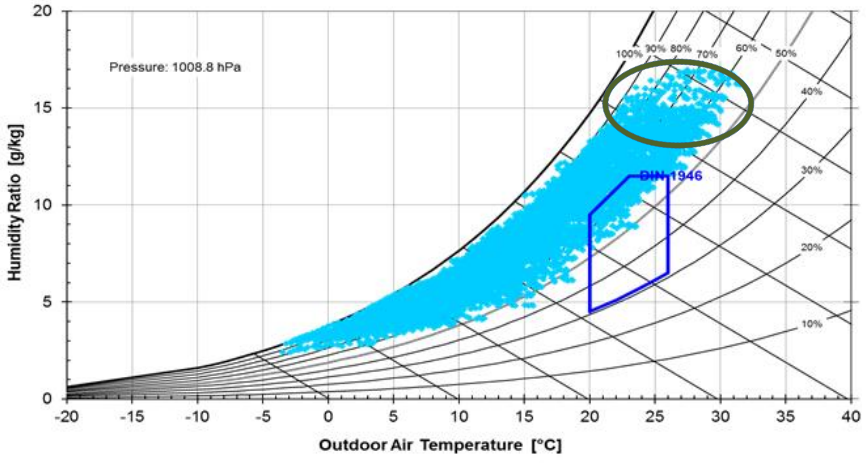
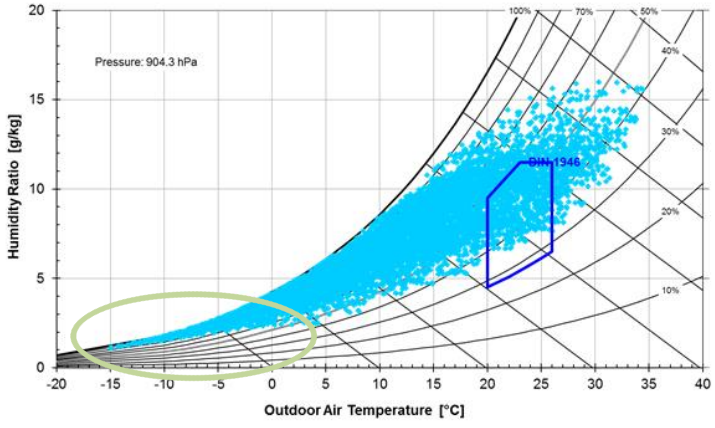
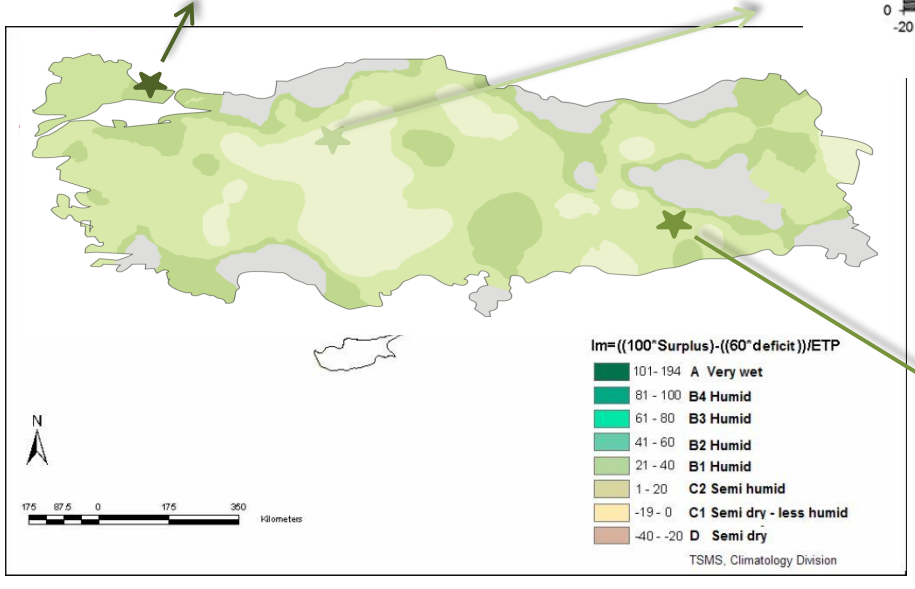
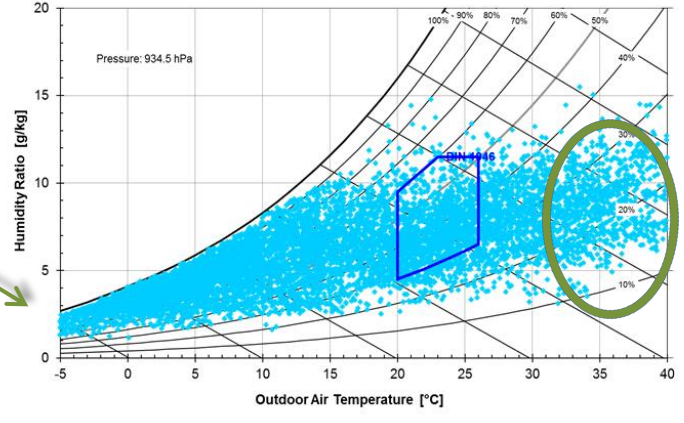
TMY2 IstanbulAtaturk



TMY2 Esenboga







24H/D Operation Time 0h - 24h

My Thesis Study Results

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- overcome COST barrier
- convience the CLIENT
- increase the knowledge in the sector

OUTLINE

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ANKARA - DIYARBAKIR - ISTANBUL

1- Building Envelope Optimization

2- System Optimization

3- Primary Energy Sources (Geothermal, PV, Solar Panels)

4- LCC of applied strategies

Simulation Parameters

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Internal Gains

Offices,

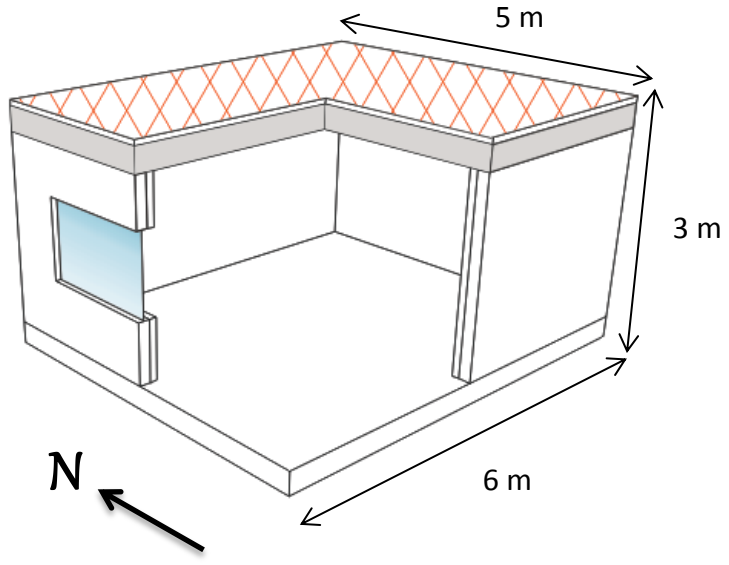
2 people - 75 Watt /each
2 computer - 70 Watt / each
12 W/m^2 (500 lux level - lighting load)

Work Schedule between 08:00-19:00

Residential,

1 people - 75 Watt
5 W/m^2 (300 lux level - lighting load)
3.4 W/m^2 (other loads, fridge, TV, etc.)

Work Schedule 24 hours



Heating

Set point temperature: 19°C (Operative)

Cooling

Set point temperature: 26°C (Operative)

Ventilation

30m^3/h per person

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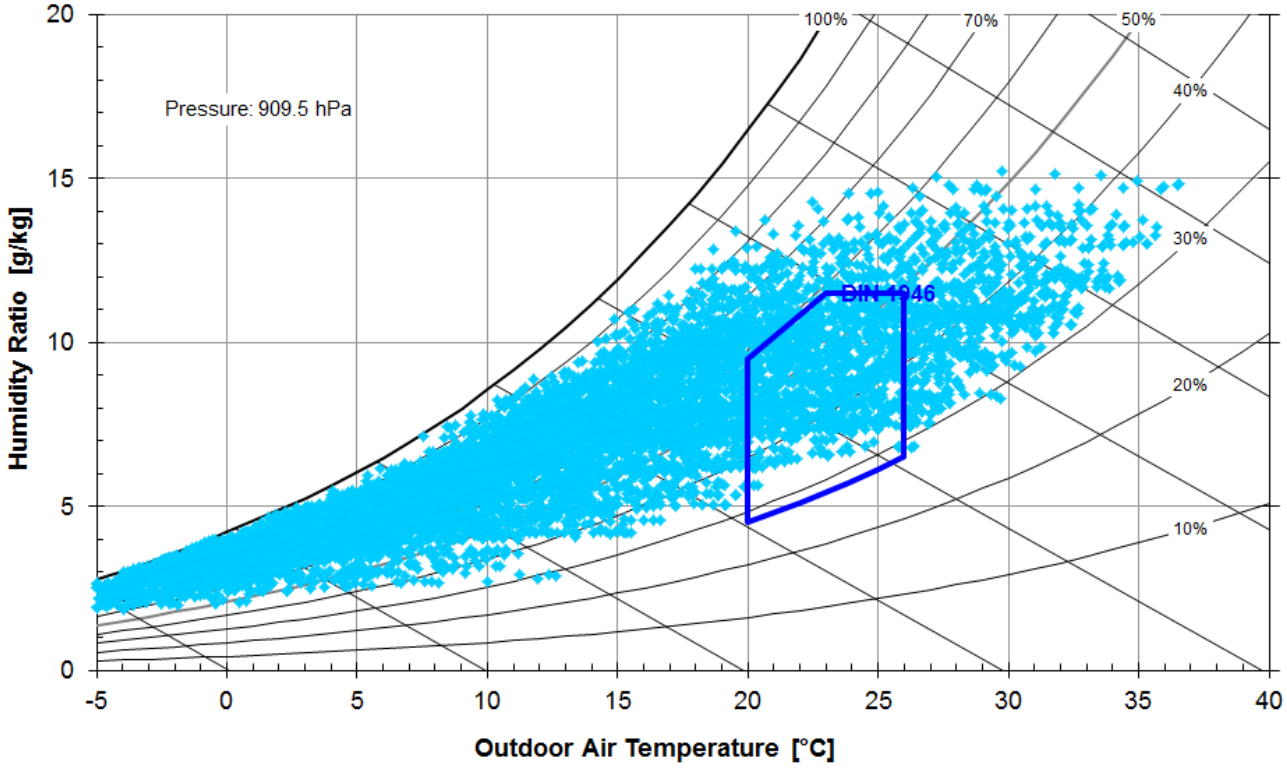

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to improve Building Envelope...

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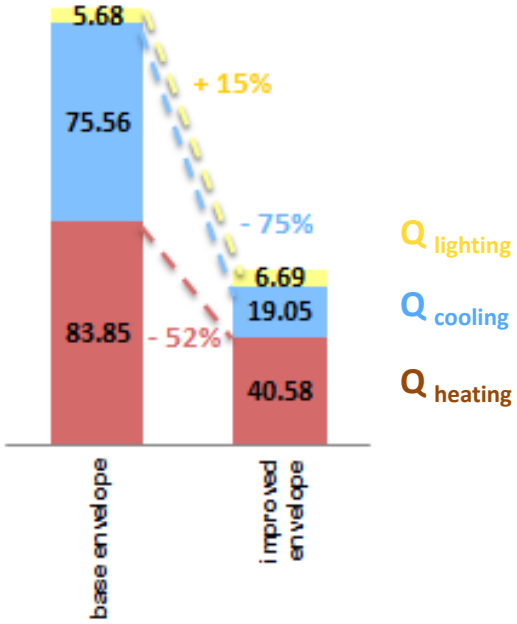
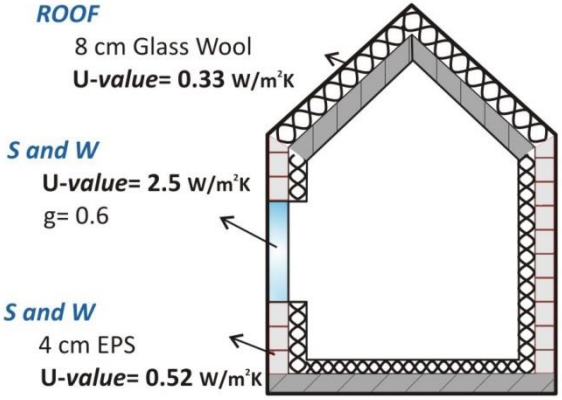
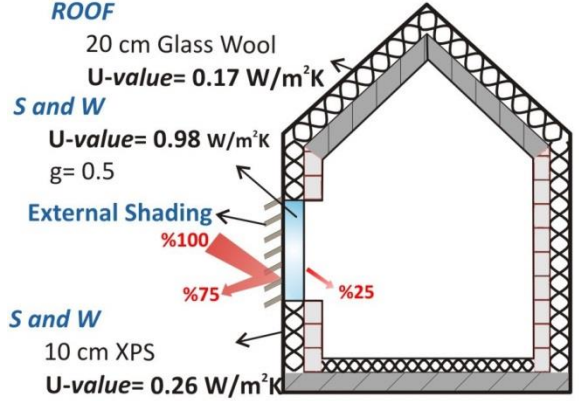


in kWh/m²

Base Envelope



Improved Envelope



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to optimize Building Systems...

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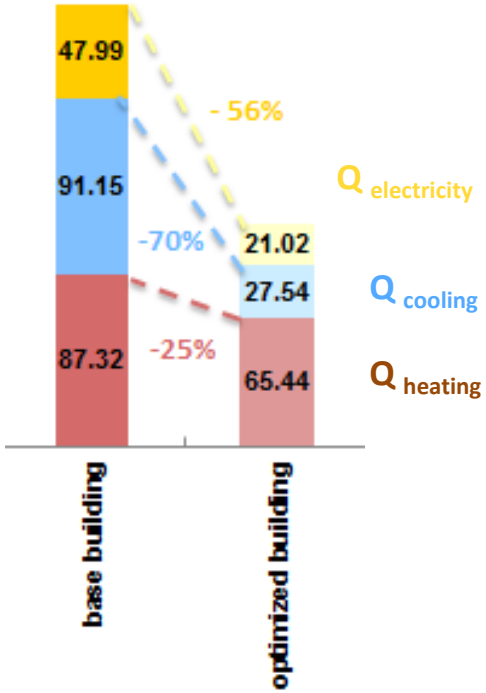
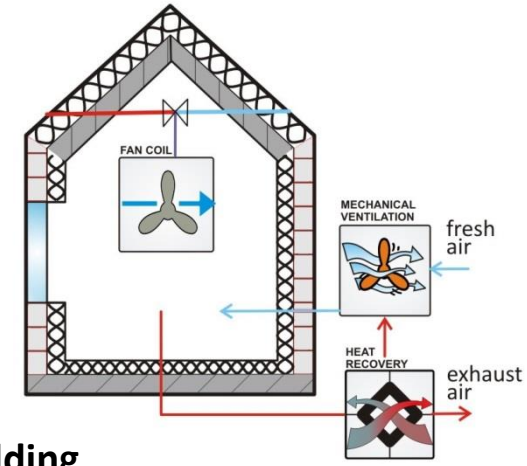
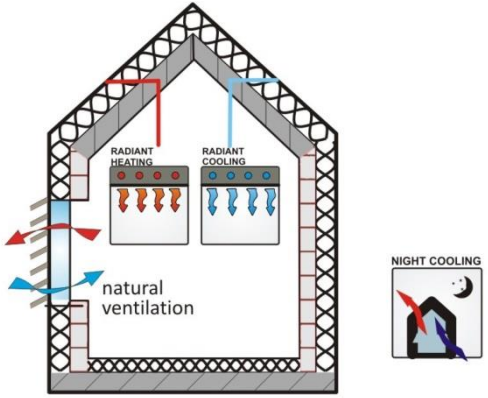


in kWh/m²

Base Building



Optimized Building



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to calculate PRIMARY ENERGY FACTOR...

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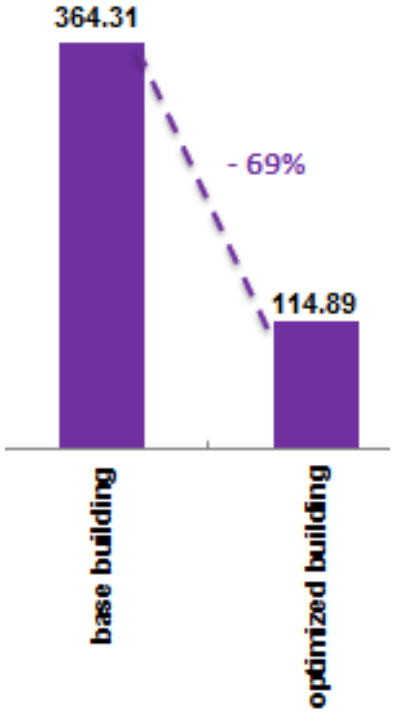
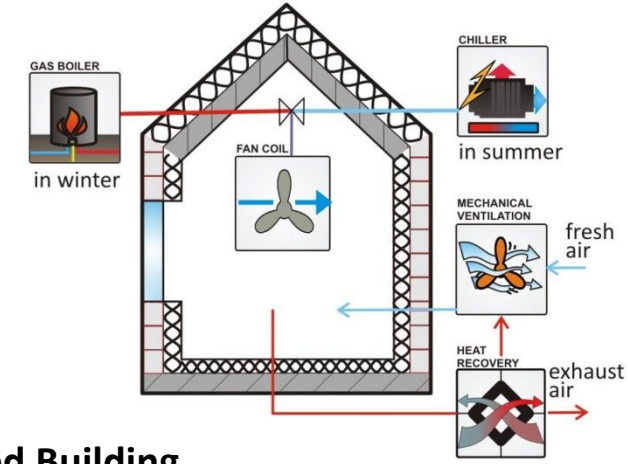
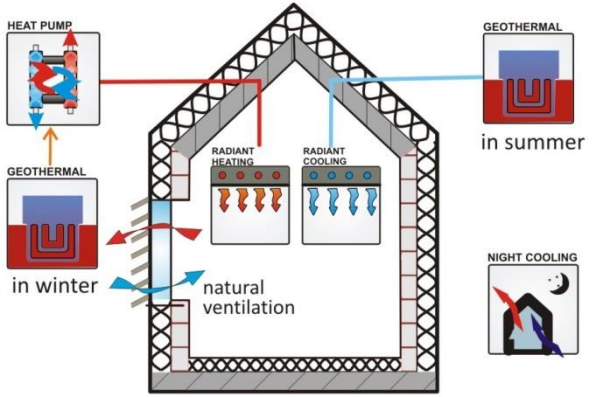


in terms of electricity

Base Building



Optimized Building



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in terms of comfort...

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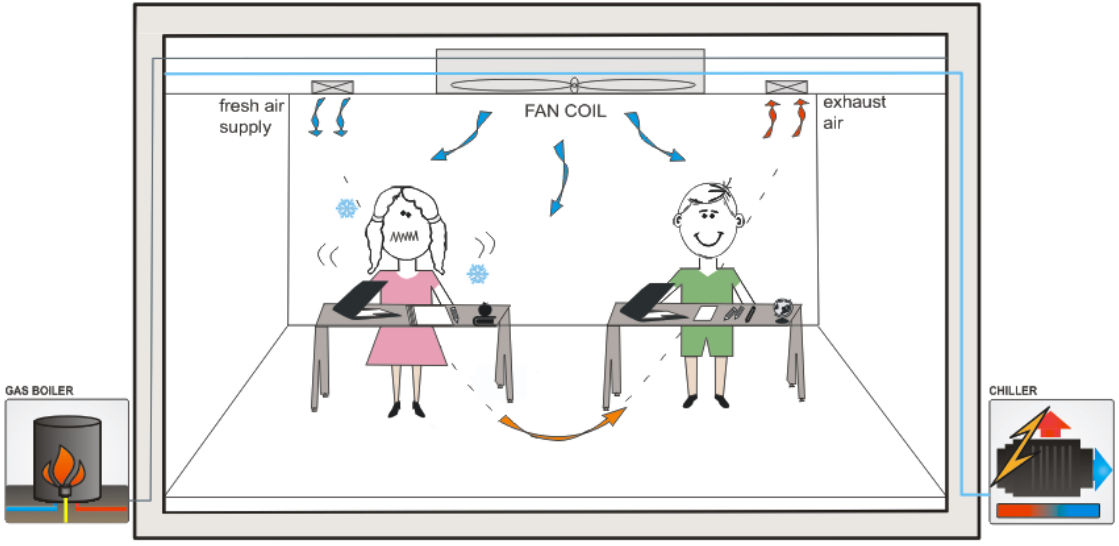
Base Building



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in terms of comfort...

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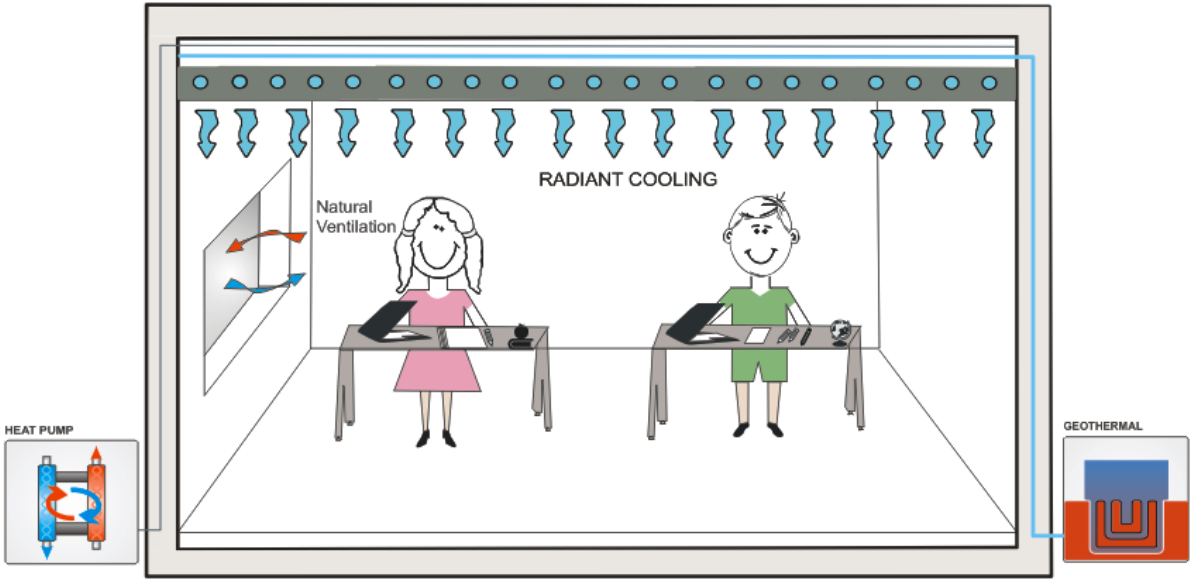
Optimized Building



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LIFE CYCLE COSTING

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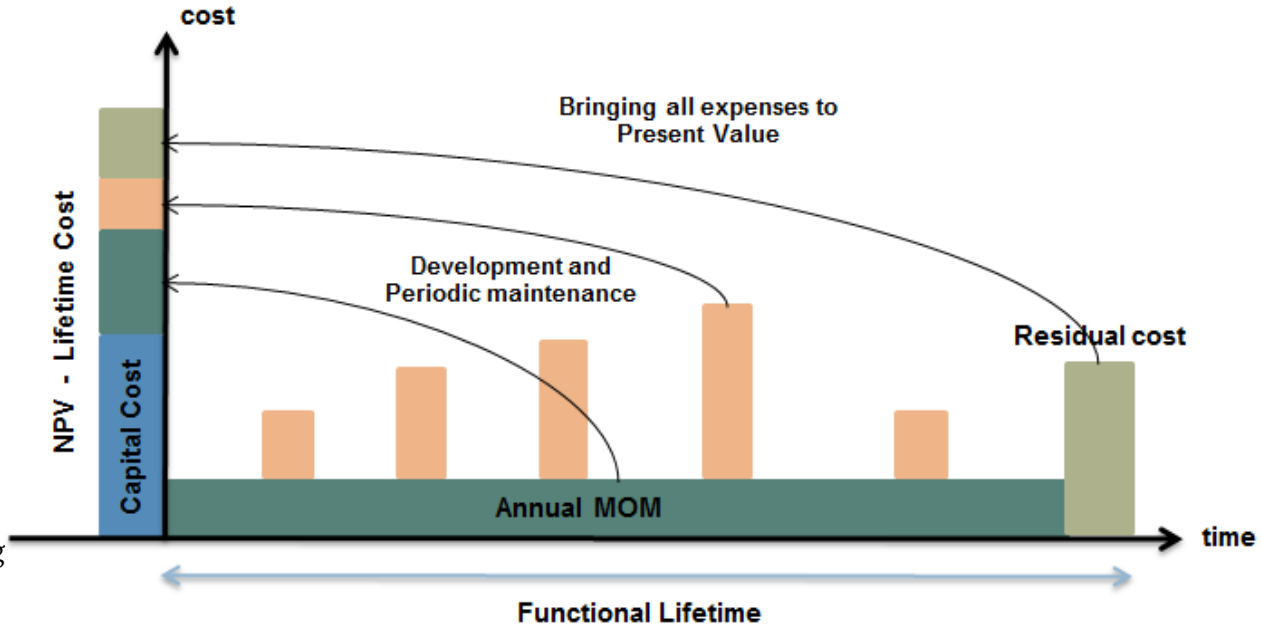

Capital Cost
Project Cost
HVAC and plumbing

Development Cost
Current refurbishment
Replacement

Maintenance Cost
Taxes
Insurance

Operation Cost
Energy

SNAPSHOT OF LCC EXCEL TOOL

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General Information		
Electiricity Cost	0.13	Euro/kWh
Natural Gas	0.04	Euro/kWh
Interest Rate	6.00%	%
Discount Rate	15.00%	%

Info !!! :)

assumed that, all of the materials have a **20** heating and ventilation systems have **20** cooling systems have **15** years lifetime

UTILITY COST (Euro/kWh)	Escalation Rate (%)		years	0	1	2	3	4	5	6	7	8	9
	Electiricity	Natural Gas	Electiricity	0.13	0.14	0.16	0.17	0.19	0.21	0.23	0.25	0.28	0.31
	10.29%	9.04%	Natural Gas	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08

BASE BUILDING

	HEATING			COOLING			ELECTRICITY			MATERIALS			
Intial Cost / Investment (Euro/m²)	4.31			12.60			11.71			2.12	4.22	0.00	5.17
NPV of Annual Cost (Euro/m²)	38.30			71.89			82.65			0.00	0.00	0.00	0.00
YEARS	Consumption (kWh/m²)	Energy Cost (Euro/m²)	M & O Cost (Euro/m²)	Consumption (kWh/m²)	Energy Cost (Euro/m²)	M & O Cost (Euro/m²)	Consumption (kWh/m²)	Energy Cost (Euro/m²)	M & O Cost (Euro/m²)	Wall (Euro/m²)	Window (Euro/m²)	Shading (Euro/m²)	Roof (Euro/m²)
1	87.32	3.41	0.13	41.4	5.8		47.99	6.8	0.19				
2	87.32	3.72	0.13	41.4	6.4		47.99	7.5	0.19				
3	87.32	4.06	0.13	41.4	7.1		47.99	8.2	0.19				
4	87.32	4.42	0.13	41.4	7.8		47.99	9.1	0.19				
5	87.32	4.82	0.13	41.4	8.6		47.99	10.0	0.19				
6	87.32	5.26	0.13	41.4	9.5		47.99	11.0	0.19				
7	87.32	5.73	0.13	41.4	10.5		47.99	12.2	0.19				
8	87.32	6.25	0.13	41.4	11.6		47.99	13.4	0.19				
9	87.32	6.82	0.13	41.4	12.8		47.99	14.8	0.19				
10	87.32	7.43	0.13	41.4	14.1		47.99	16.4	0.19				
11	87.32	8.11	0.13	41.4	15.6		47.99	18.0	0.19				
12	87.32	8.84	0.13	41.4	17.2		47.99	19.9	0.19				
13	87.32	9.64	0.13	41.4	18.9		47.99	21.9	0.19				
14	87.32	10.51	0.13	41.4	20.9		47.99	24.2	0.19				
15	87.32	11.46	0.13	41.4	23.0	12.60	47.99	26.7	0.19				
16	87.32	12.50	0.13	41.4	25.4		47.99	29.4	0.19				
17	87.32	13.63	0.13	41.4	28.0		47.99	32.5	0.19				
18	87.32	14.86	0.13	41.4	30.9		47.99	35.8	0.19				
19	87.32	16.21	0.13	41.4	34.1		47.99	39.5	0.19				
20	87.32	17.67	0.13	41.4	37.6		47.99	43.6	0.19				

LCC OF OPTIMIZED BUILDING

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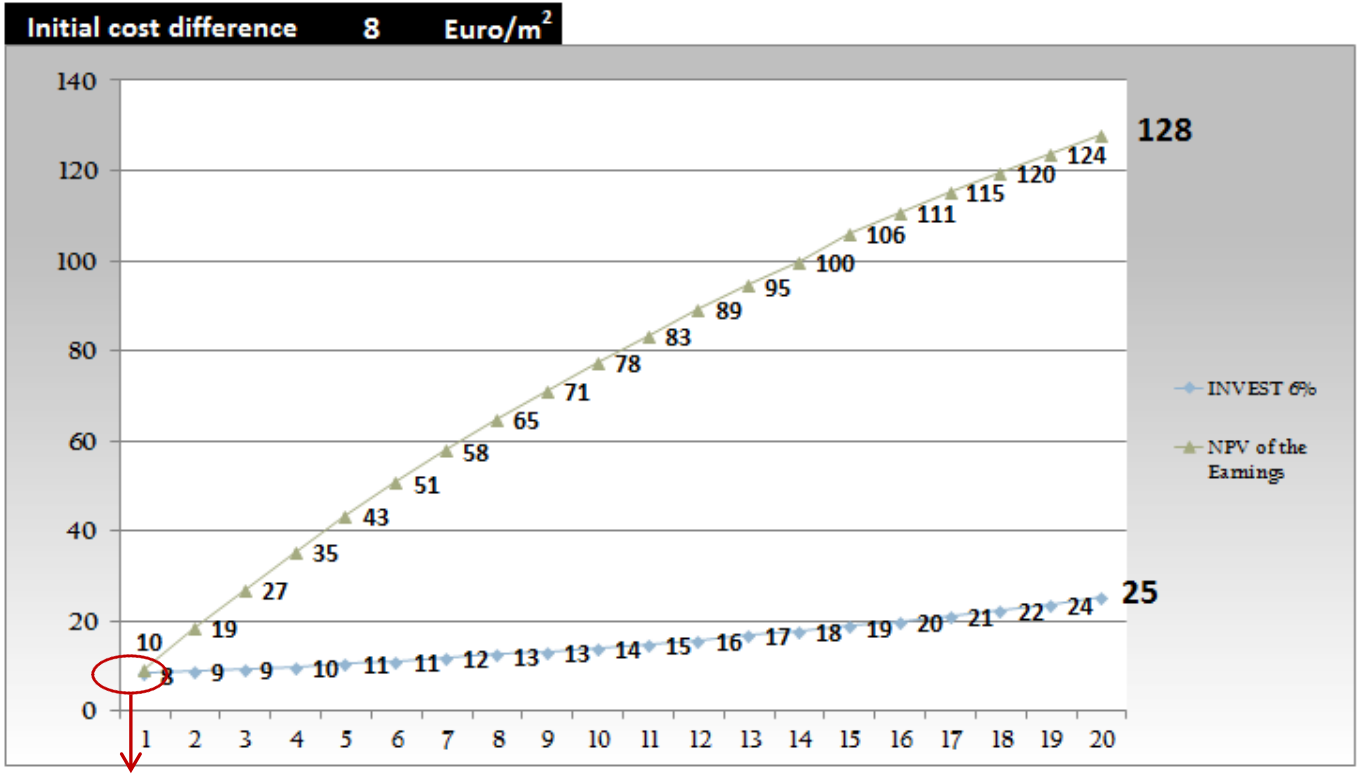
BASE BUILDING	
ITEMS	COST (Euro/m^2)
HEATING	4.31
COOLING	12.60
VENTILATION	11.71
MATERIAL	11.51
TOTAL	**40.13**

OPTIMIZED BUILDING	
ITEMS	COST (Euro/m^2)
HEATING	13.92
COOLING	
VENTILATION	0.00
MATERIAL	34.07
TOTAL	**47.99**



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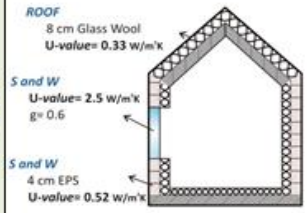
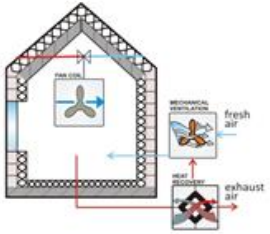
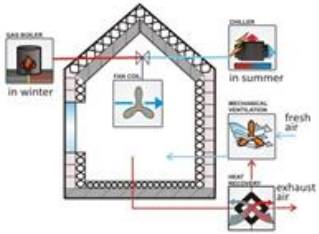
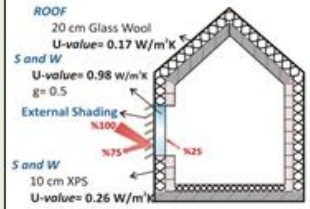
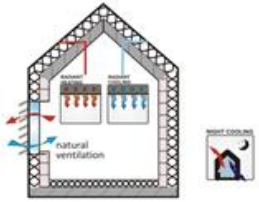
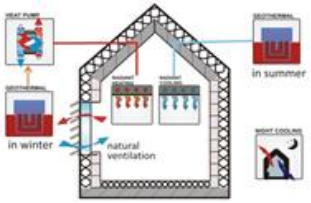
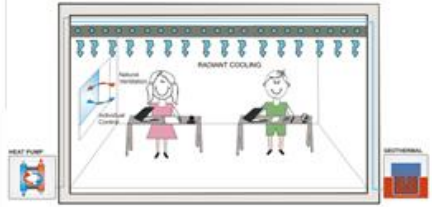
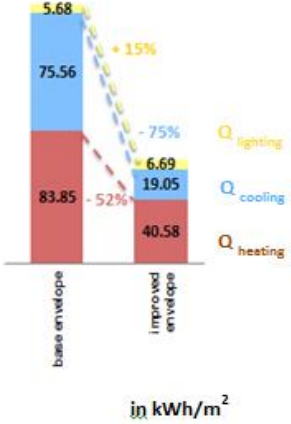
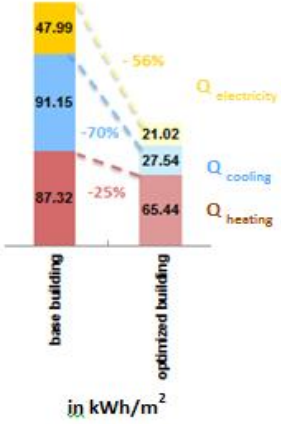
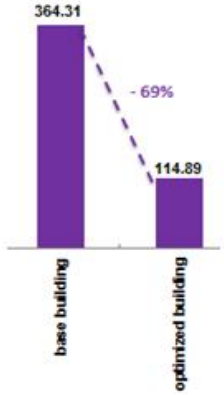
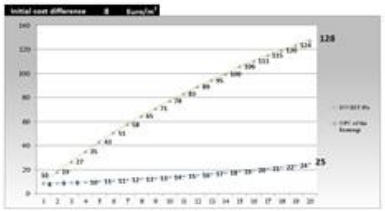
(office)

	Envelope (Reduce the demand)	Systems (Prefer high efficiency)	Primary Energy Factor (reduce the energy consumption)	Comfort (Create More Comfortable Spaces)	COST (save more money)
BASE					**BASE BUILDING** ITEMS / COST (Euro/m²) HEATING 4.31 COOLING 12.60 VENTILATION 11.71 MATERIAL 11.51 *TOTAL* **40.13**
OPTIMIZED					**OPTIMIZED BUILDING** ITEMS / COST (Euro/m²) HEATING / COOLING 13.92 VENTILATION 0.00 MATERIAL 34.07 *TOTAL* **47.99**
RESULTS				+ Coupling heating/cooling with thermal mass reduces peak load + Longer natural ventilation season due to higher surface temperature + Higher chilled water and low hot water supply temperatures provide high potential for energy savings + Low initial cost due to integration with structural slab + No maintenance - Response time of several hours, no instant heating/cooling - Increased condensation risk due to slower responsive time - Acoustic concerns must be handled separately	 **ANKARA (office)**

ISTANBUL

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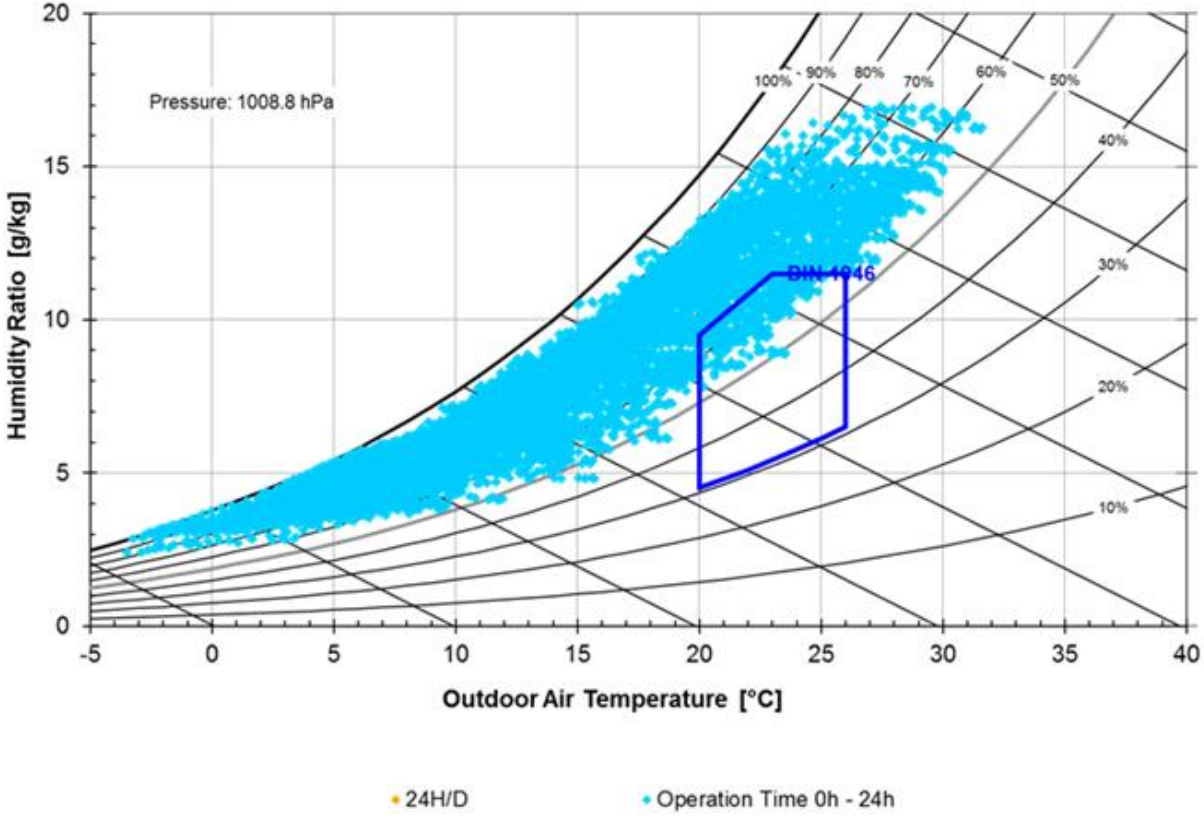
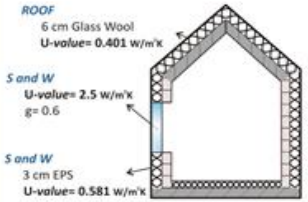
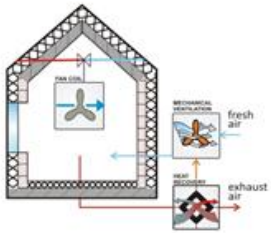
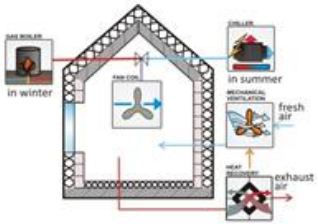
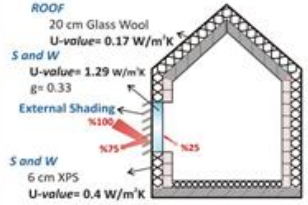
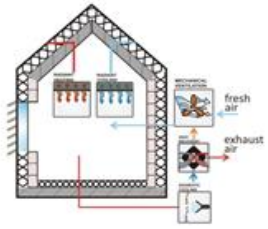
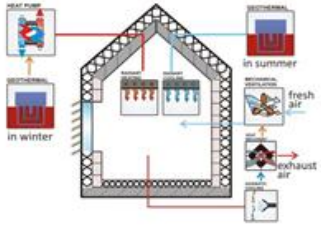
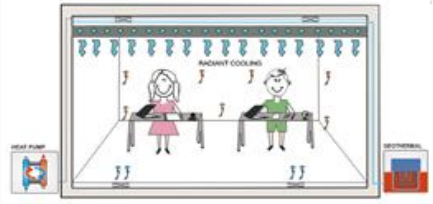
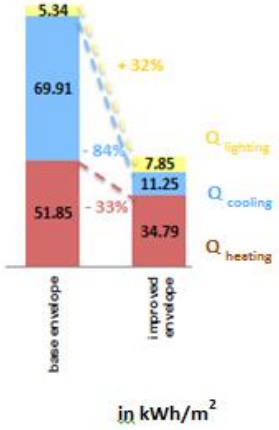
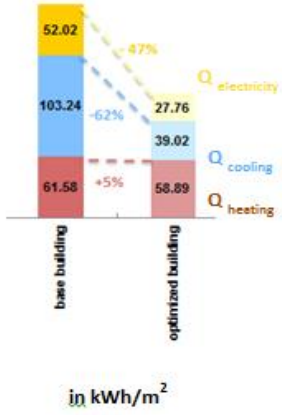
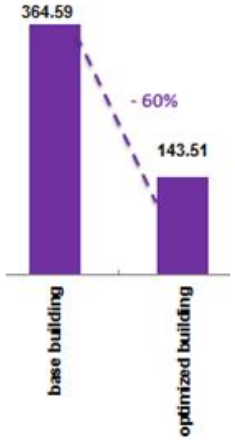
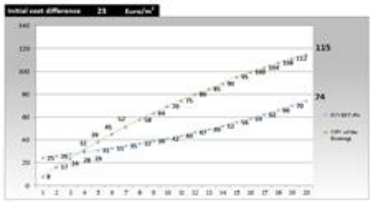


ISTANBUL
(office)

	Envelope (Reduce the demand)	Systems (Prefer high efficiency)	Primary Energy Factor (reduce the energy consumption)	Comfort (Create More Comfortable Spaces)	COST (save more money)
BASE					**BASE BUILDING** ITEMS / COST (Euro/m²) HEATING 4.31 COOLING 12.60 VENTILATION 12.17 MATERIAL 10.26 *TOTAL* **39.34**
OPTIMIZED					**OPTIMIZED BUILDING** ITEMS / COST (Euro/m²) HEATING 15.31 COOLING 3.31 VENTILATION 12.17 MATERIAL 31.74 *TOTAL* **62.54**
RESULTS				+ Coupling heating/cooling with thermal mass reduces peak load + Longer natural ventilation season due to higher surface temperature + Higher chilled water and low hot water supply temperatures provide high potential for energy savings + Low initial cost due to integration with structural slab + No maintenance - Response time of several hours, no instant heating/cooling - Increased condensation risk due to slower responsive time - Acoustic concerns must be handled separately	 **ISTANBUL (office)**

LCC OF OPTIMIZED BUILDING

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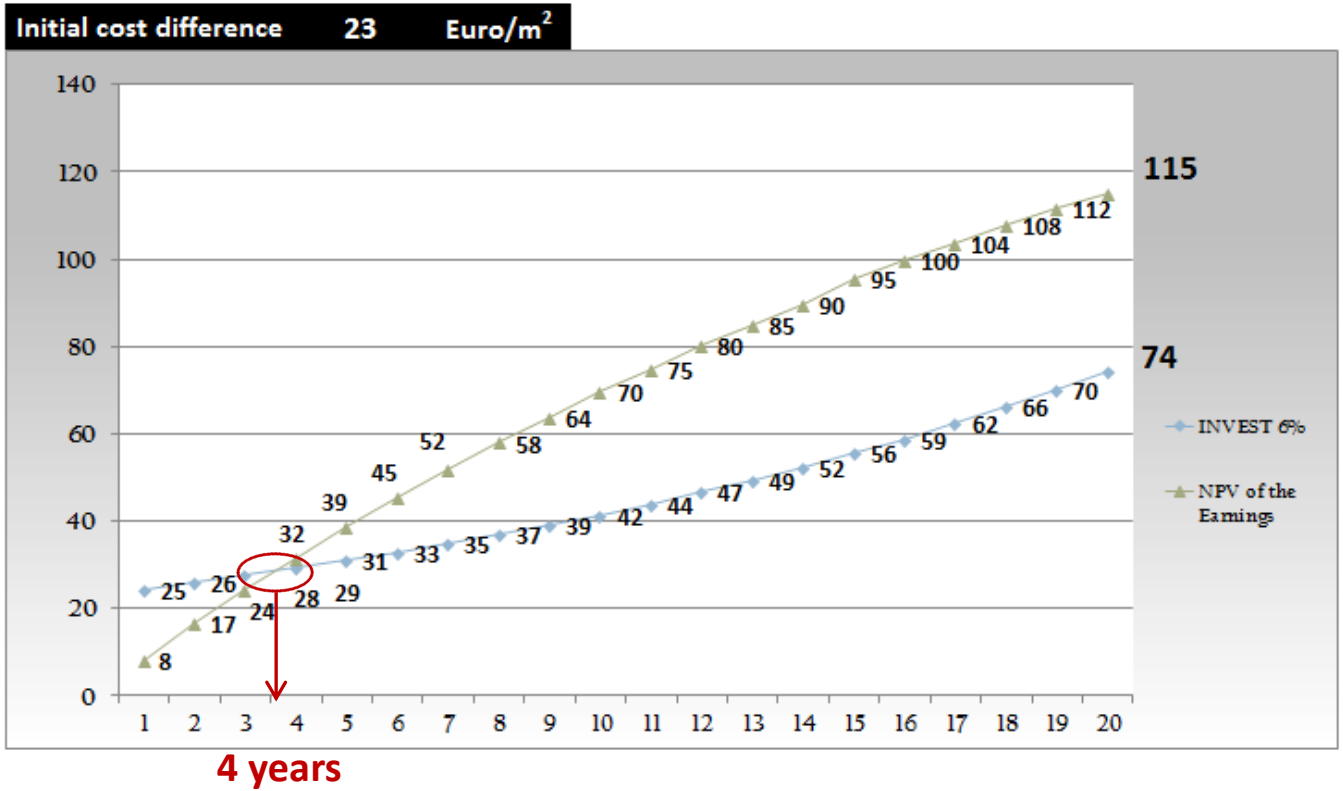
BASE BUILDING	
ITEMS	COST (Euro/m^2)
HEATING	4.31
COOLING	12.60
VENTILATION	12.17
MATERIAL	10.26
TOTAL	**39.34**

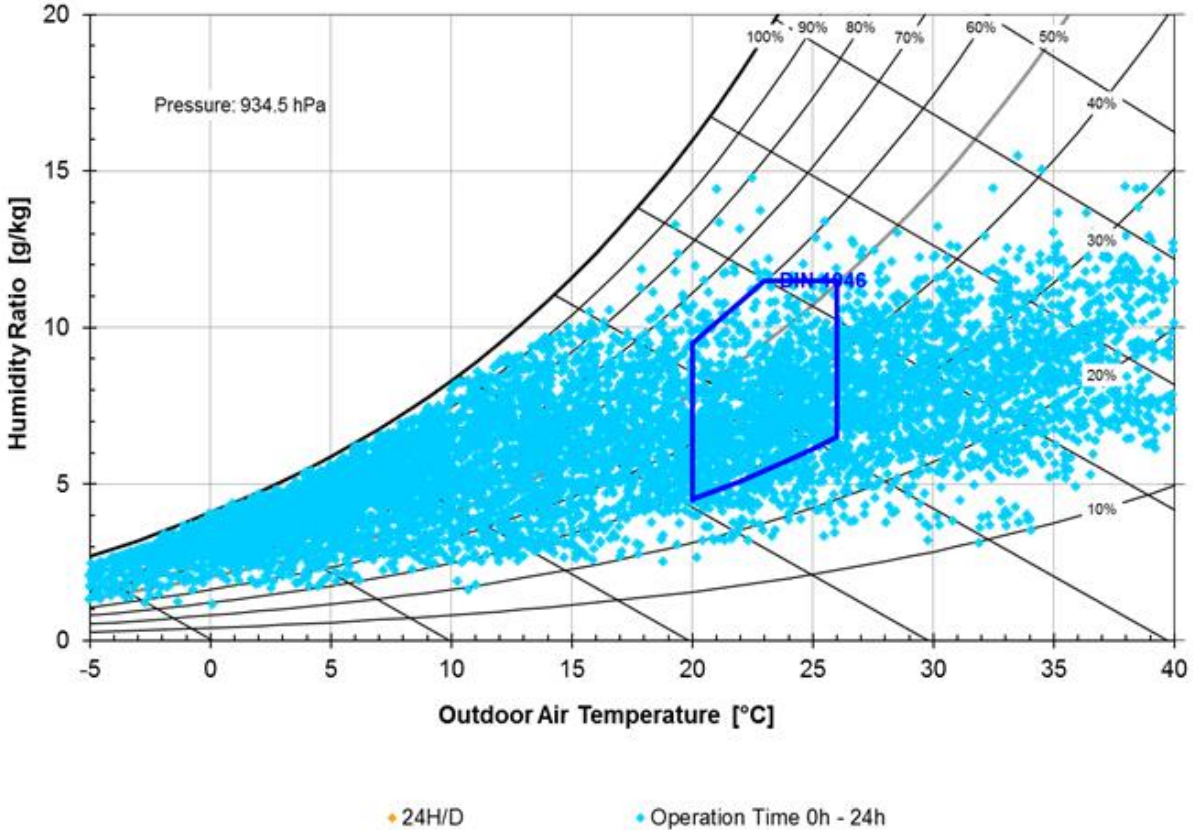
OPTIMIZED BUILDING	
ITEMS	COST (Euro/m^2)
HEATING	15.31
COOLING	3.31
VENTILATION	12.17
MATERIAL	31.74
TOTAL	**62.54**



ISTANBUL
(office)

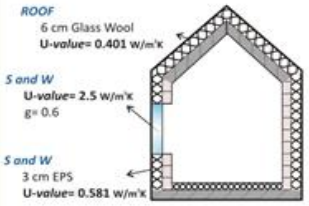
DIYARBAKIR

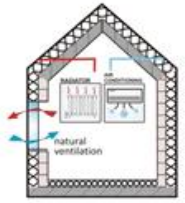
Transsolar academy

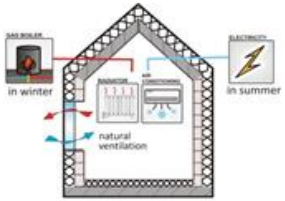


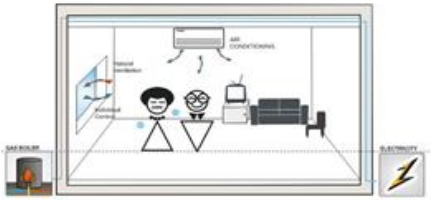
DIYARBAKIR
(residential)

Envelope (Reduce the demand)	Systems (Prefer high efficiency)	Primary Energy Factor (reduce the energy consumption)	Comfort (Create More Comfortable Spaces)	COST (save more money)

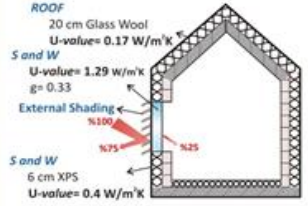


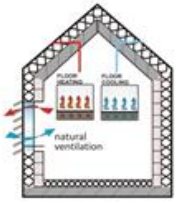


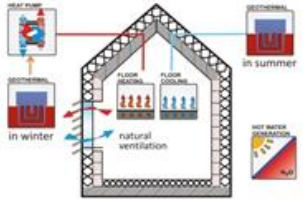


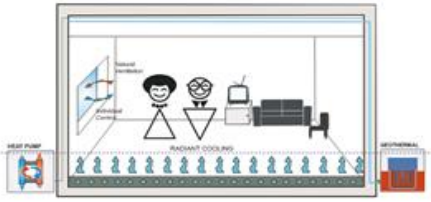


BASE BUILDING	
ITEMS	COST (Euro/m²)
HEATING	14.69
COOLING	12.24
VENTILATION	0.00
MATERIAL	10.26
TOTAL	37.18

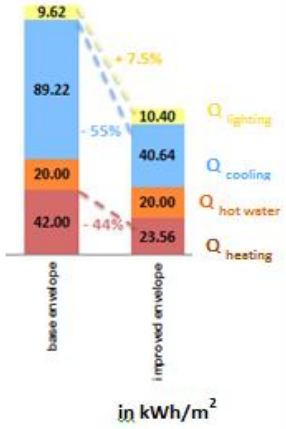


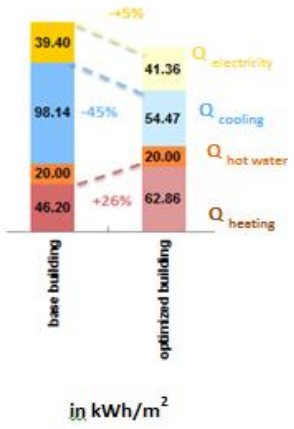


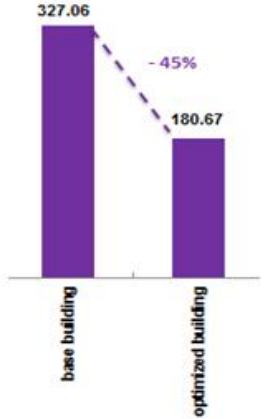




OPTIMIZED BUILDING	
ITEMS	COST (Euro/m²)
HEATING	33.69
COOLING	
VENTILATION	0.00
MATERIAL	15.36
TOTAL	49.06







+ Coupling heating/cooling with thermal mass reduces peak load
+ Longer natural ventilation season due to higher surface temperature
+ Higher chilled water and low hot water supply temperatures provide high potential for energy savings
+ Low initial cost due to integration with structural slab
+ No maintenance

- Response time of several hours, no instant heating/cooling
- Increased condensation risk due to slower responsive time
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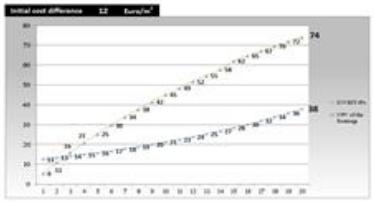

DIYARBAKIR (residential)

LCC OF OPTIMIZED BUILDING

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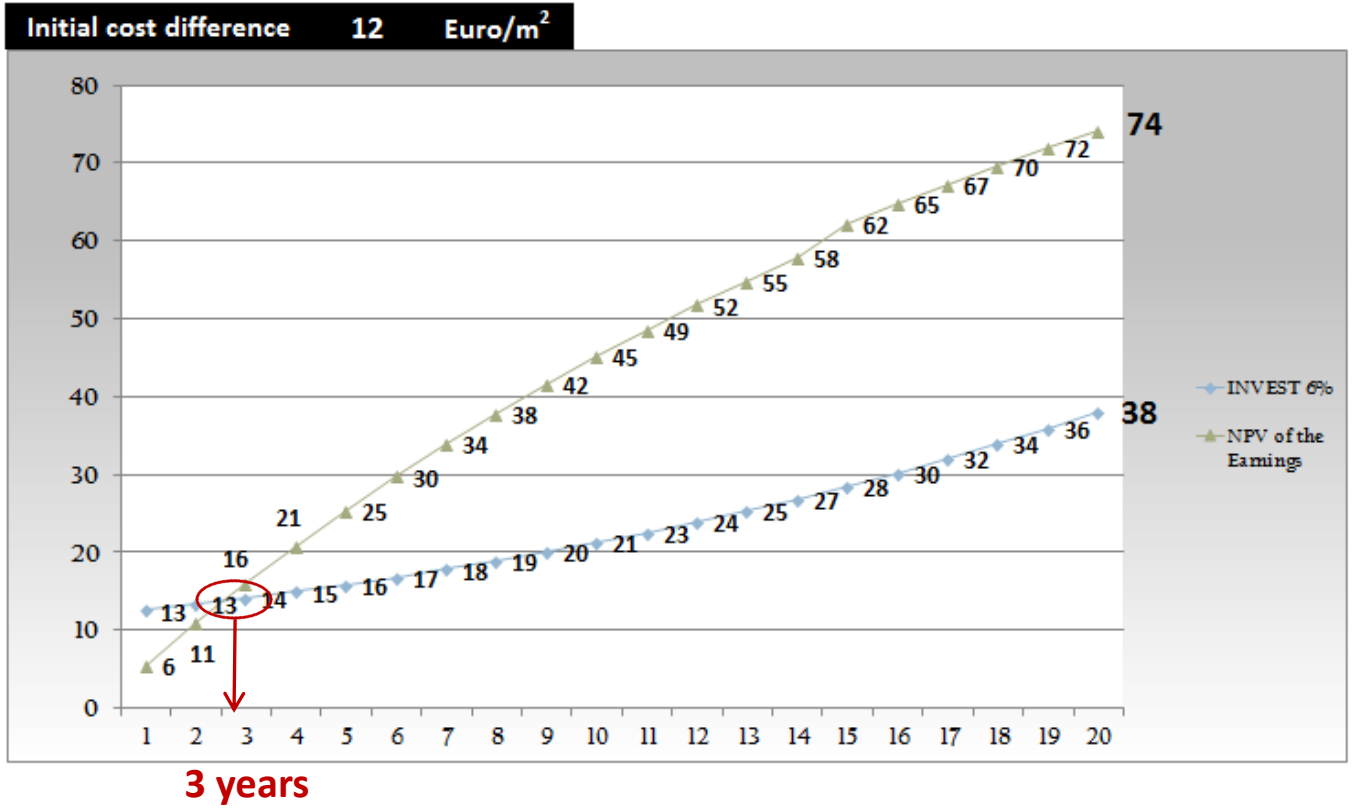
BASE BUILDING	
ITEMS	COST (Euro/m^2)
HEATING	14.69
COOLING	12.24
VENTILATION	0.00
MATERIAL	10.26
TOTAL	**37.18**

OPTIMIZED BUILDING	
ITEMS	COST (Euro/m^2)
HEATING	33.69
COOLING	
VENTILATION	0.00
MATERIAL	15.36
TOTAL	**49.06**



DIYARBAKIR
(residential)

To summarize...

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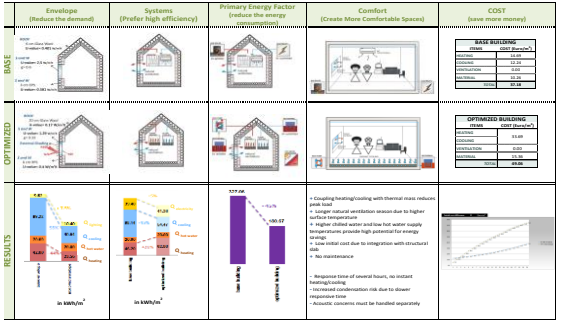
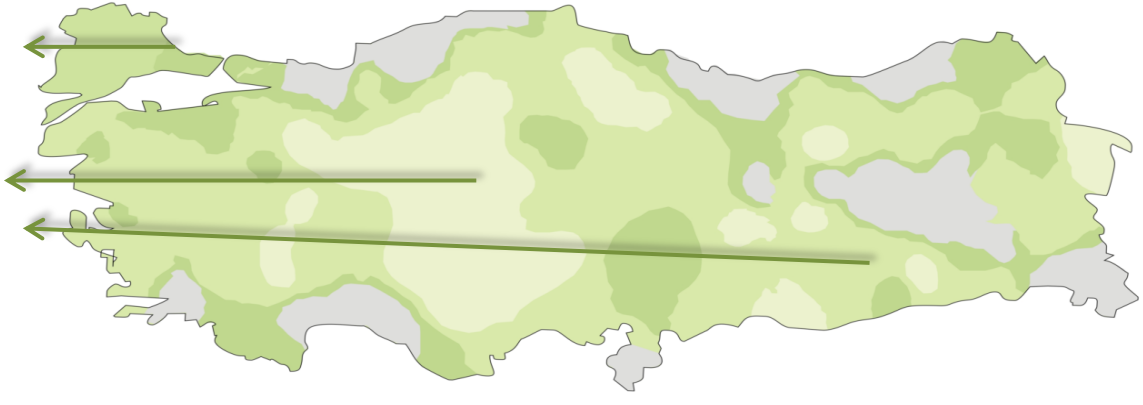
CLIMATE	Strategies	Initial Cost (Euro/m²)	Payback period (years)
ANKARA (office)	Increased insulation Natural ventilation Night Cooling	8	1
ISTANBUL (office)	Glazing Type Mechanical Ventilation	23	4
DIYARBAKIR (residential)	Fixed External Shading Floor Heating and Cooling	12	3





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VIELEN DANK !