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Ecological Application Strategies of Photovoltaic System

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Contents

- Building energy consumption & photovoltaic
- Photovoltaic & environment friendliness
- Heating & cooling load of building in Mega city
- Definition of solar architecture
- Cultural & regional composition
- Ecological view of architecture
- A model simulation for a solar architecture
- Evaluation standard for solar architecture
- Conclusions

Energy consumption and Photovoltaic(PV) harvesting

- Buildings give a severe influence in worldwide energy consumption compared to the other economic sectors (Industry and Transportation).

- Building portion (PV harvesting) to total energy consumption.

  EU : 40–45 % (PV?)

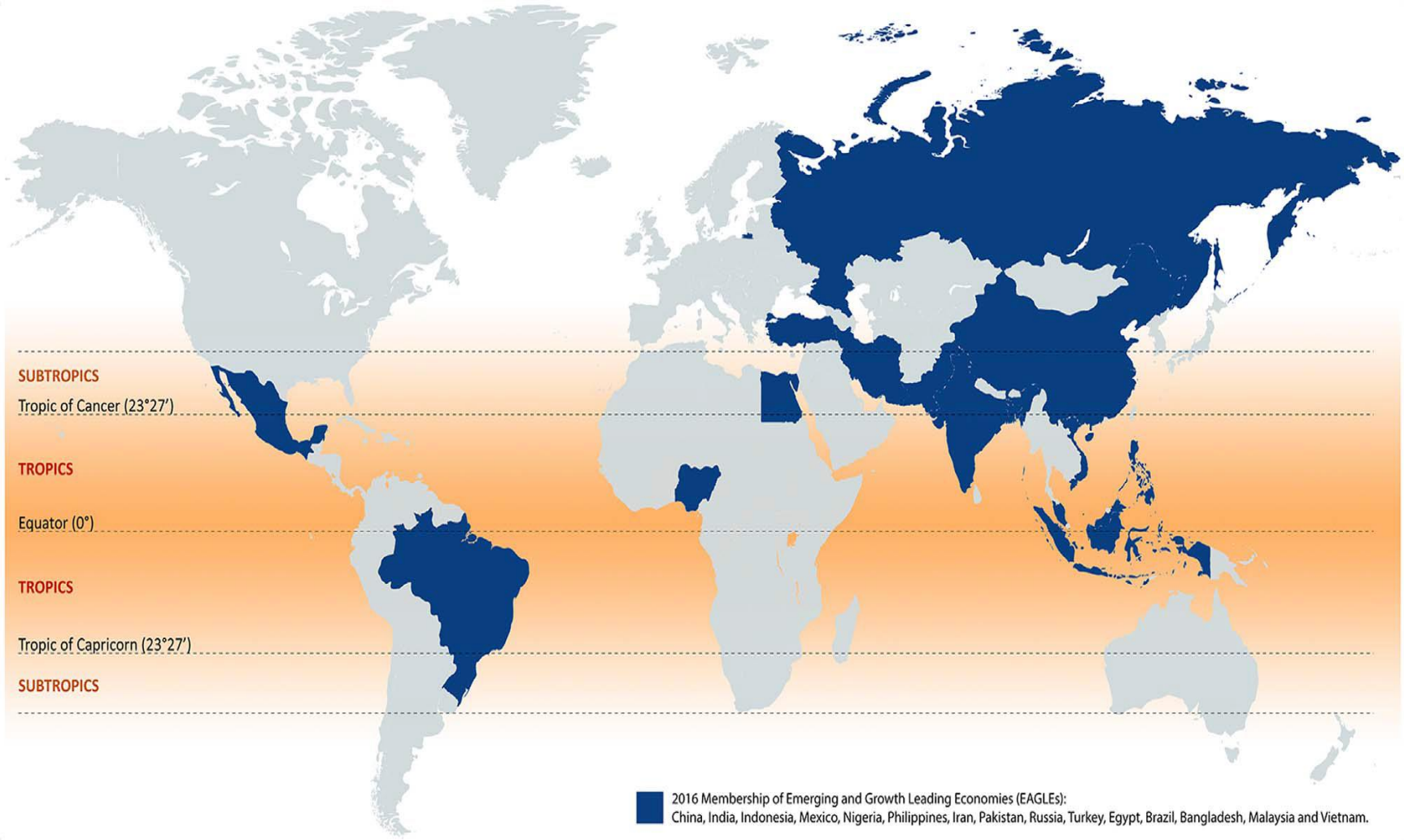
  Korea: 25 % (PV?)

  USA : 50 % (PV?)

Why an ecological application strategies ?

Building Cooling load in EAGLEs & their relative location

compared to tropical and subtropical zones



(BBVA. Emerging and Growth Leading Economies (EAGLEs). Economic Outlook. Annual Report 2016. BBVA; 2016.)

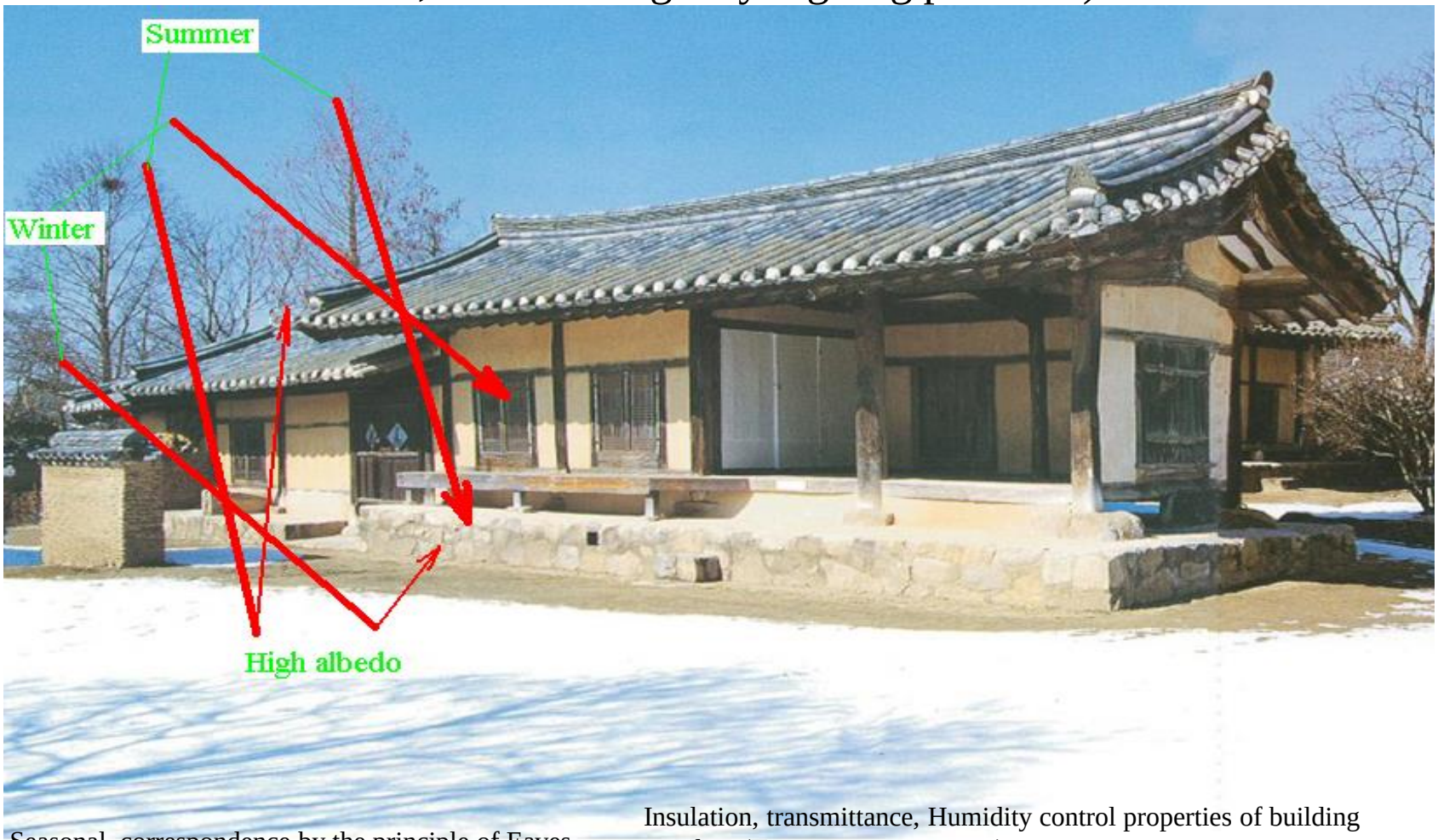
Cultural & Regional Composition

Das Iglu des Eskimo!
Maximaler Wärmeschutz
bereits durch die Formgebu

Offene Bauweise in den Tropen!

Cultural & Regional Composition

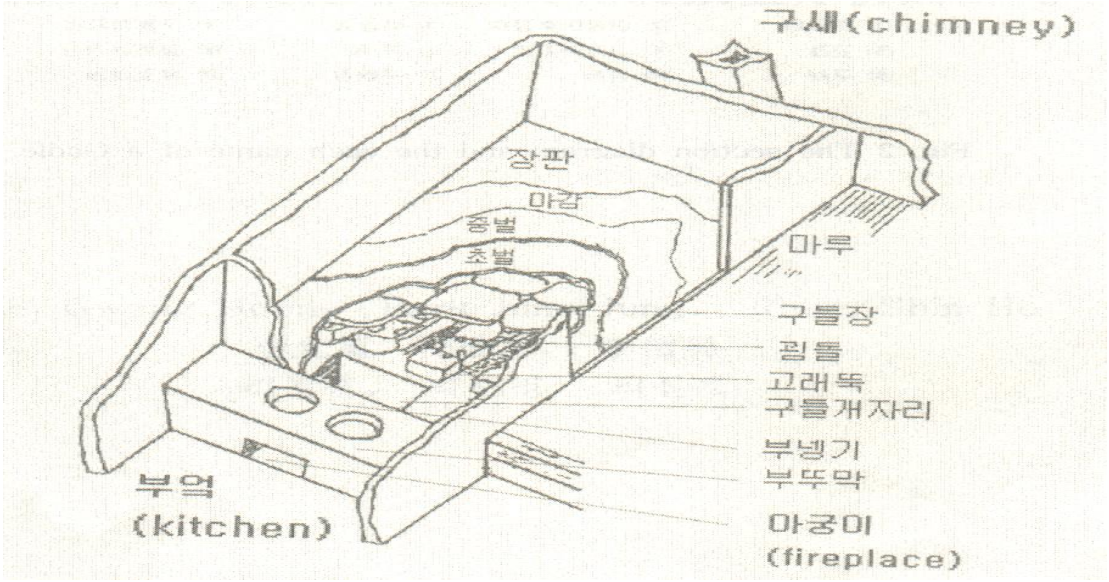
(Yang-o-dang, Jooiljae(1650-1706)(Family Ryoo's grand son,s house , Hahoi Village/Kyungsang province)

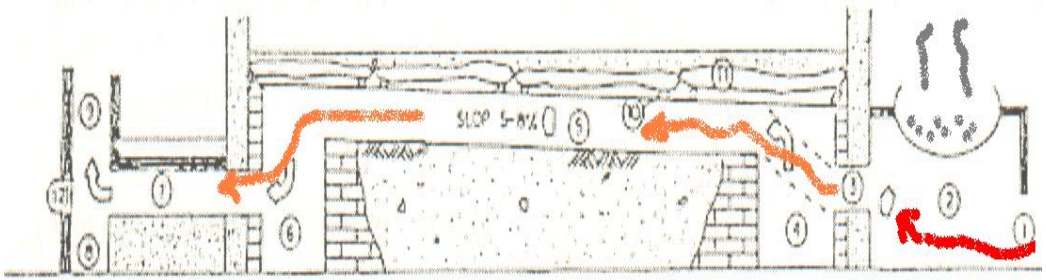


Seasonal correspondence by the principle of Eaves.
High albedo(reflectance) of front yard

Insulation, transmittance, Humidity control properties of building envelope(Transparent or opaque)
Thermal comfort and energy saving through "Ondol"(floor) heating system.

Traditional floor heating system in Korea



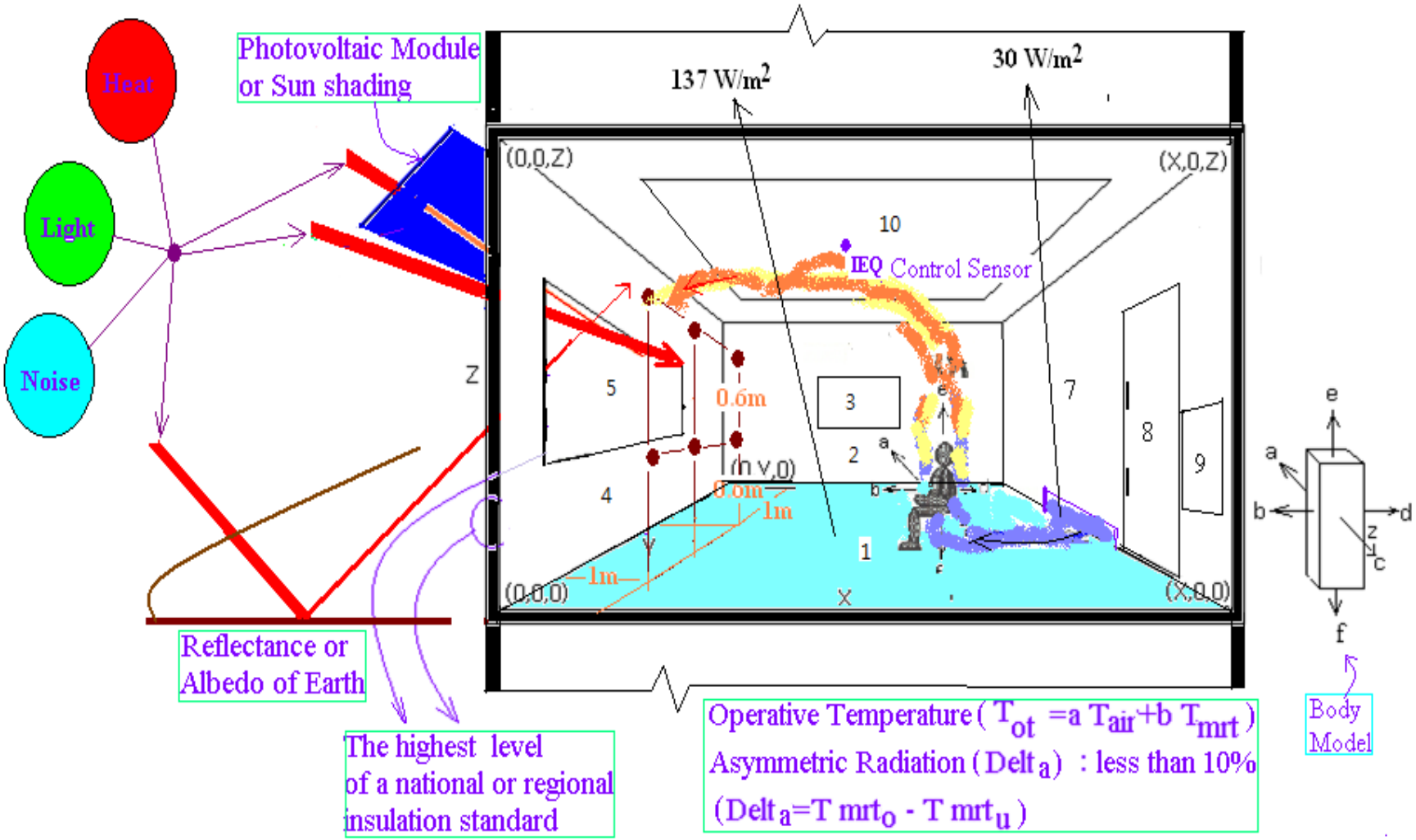


• 점선은 구들개자리가 없는 구들

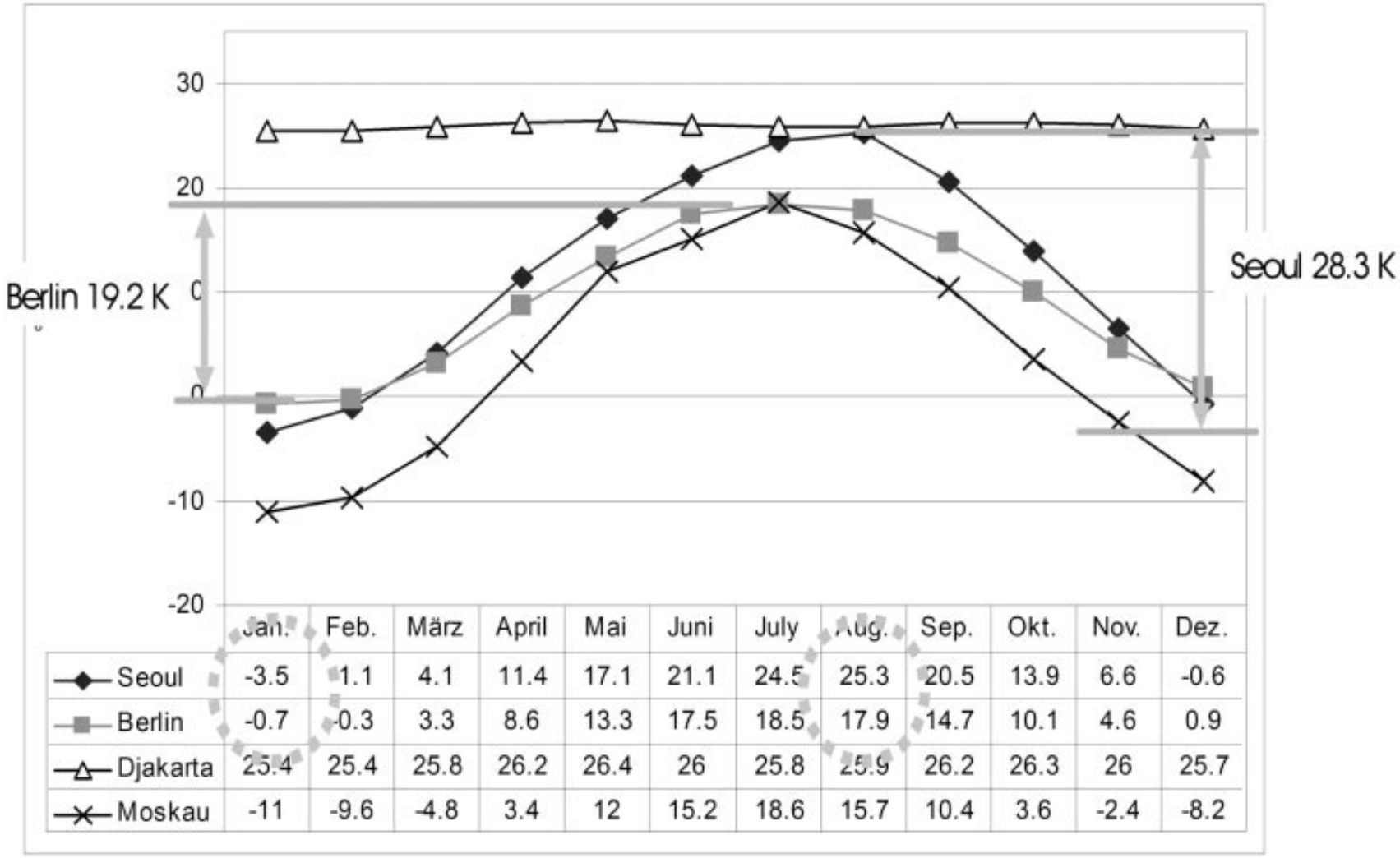
① 아궁이 ② 아궁이추렁이 ③ 부넹기 ④ 구들개자리
⑤ 고래 ⑥ 고래개자리 ⑦ 굴 뚝 ⑧ 굴뚝개자리
⑨ 구새 ⑩ 굄돌 ⑪ 구들장 ⑫ 봉알이돌

A Concept of Solar Architecture

(Ecological Fusion of Passive Solar Architecture and Photovoltaic System)



Climate Composition
(Berlin/Seoul/Djakarta/Moskau)

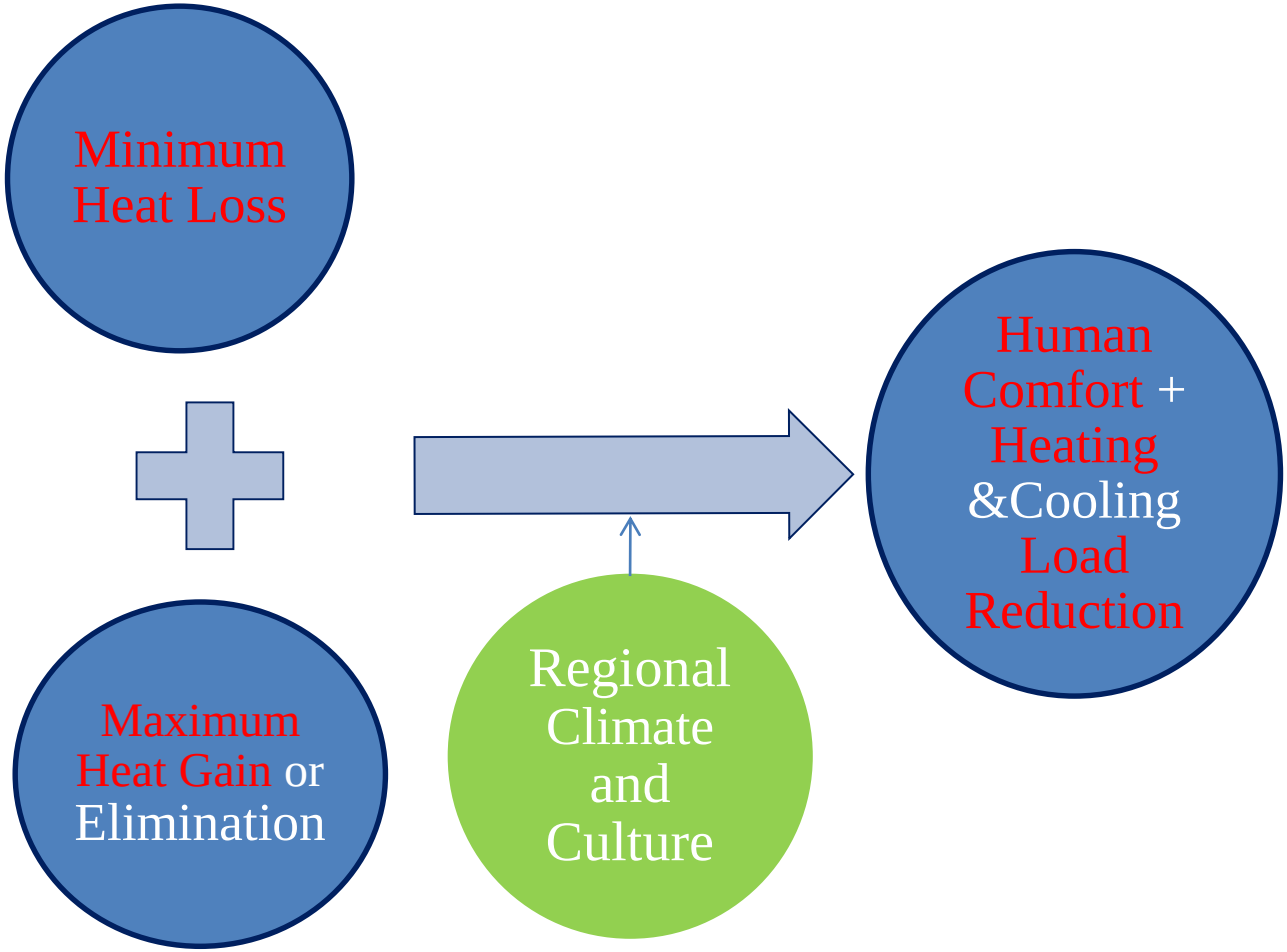


	Jan.	Feb.	März	April	Mai	Juni	July	Aug.	Sep.	Okt.	Nov.	Dez.
Seoul	-3.5	1.1	4.1	11.4	17.1	21.1	24.5	25.3	20.5	13.9	6.6	-0.6
Berlin	-0.7	-0.3	3.3	8.6	13.3	17.5	18.5	17.9	14.7	10.1	4.6	0.9
Djakarta	25.4	25.4	25.8	26.2	26.4	26	25.8	25.9	26.2	26.3	26	25.7
Moskau	-11	-9.6	-4.8	3.4	12	15.2	18.6	15.7	10.4	3.6	-2.4	-8.2

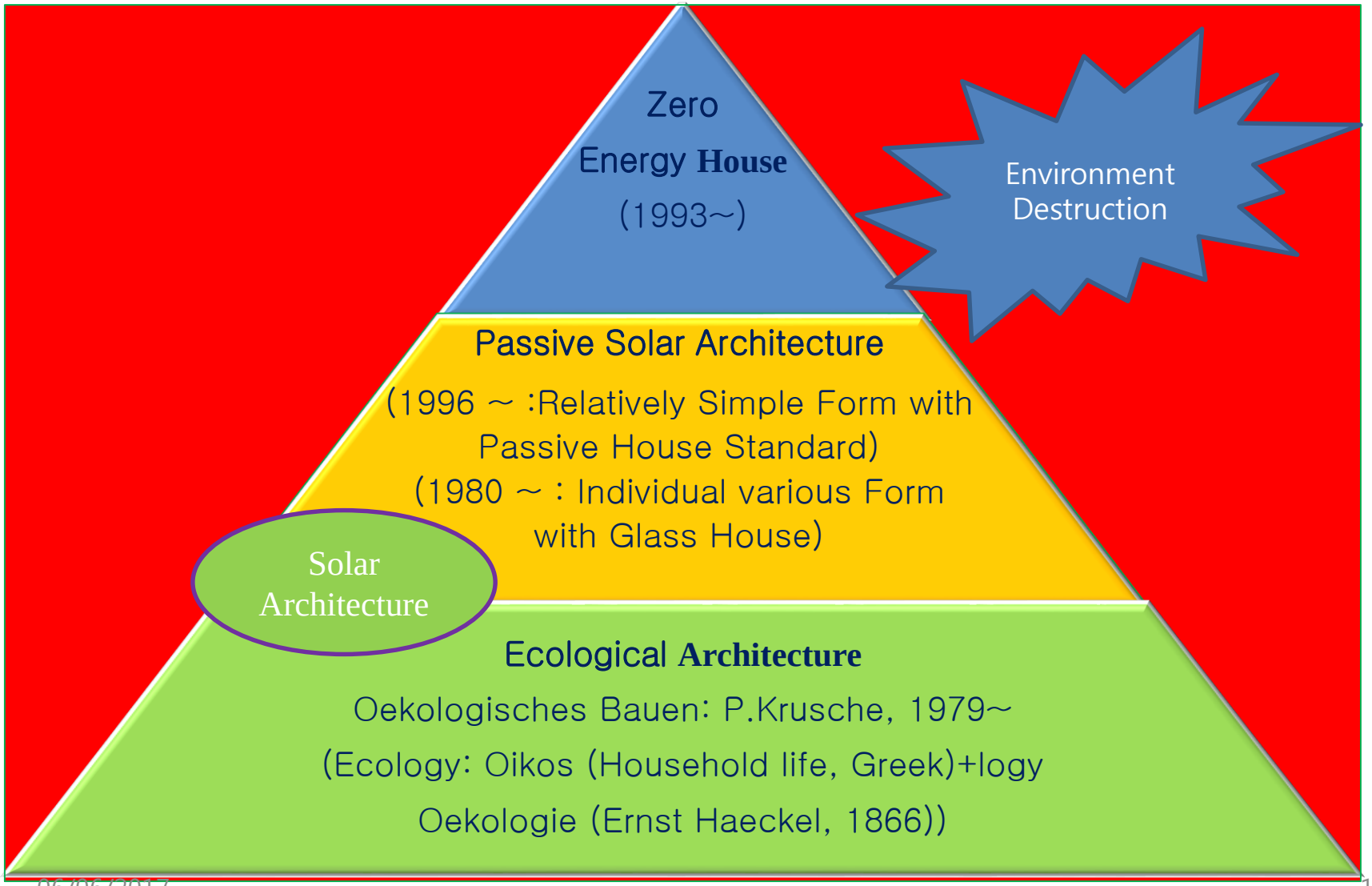
Principle of Solar Architecture

-Cultural Composition -

- **Basic Principle:**

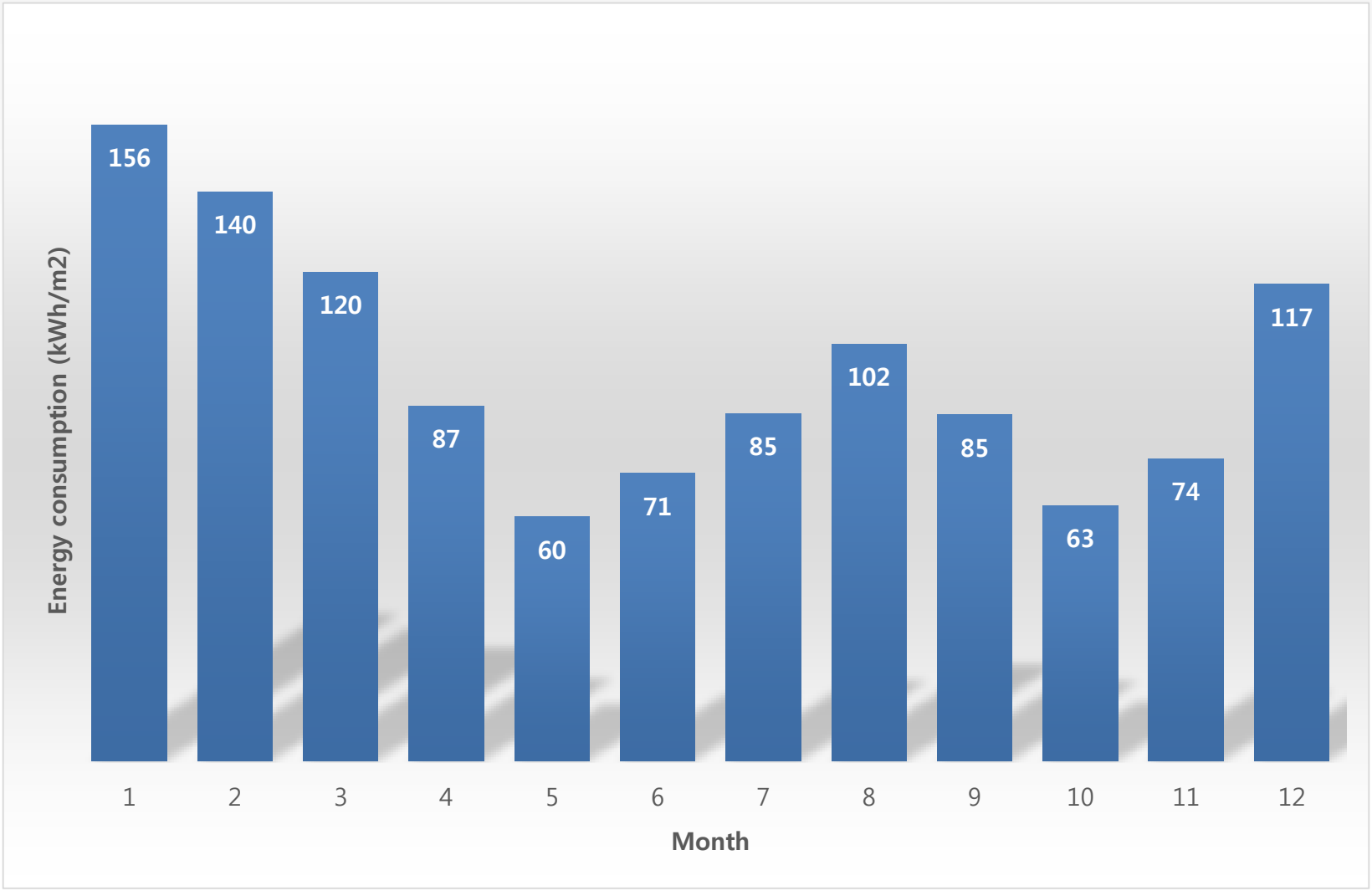


Ecological Hierarchy of Architecture



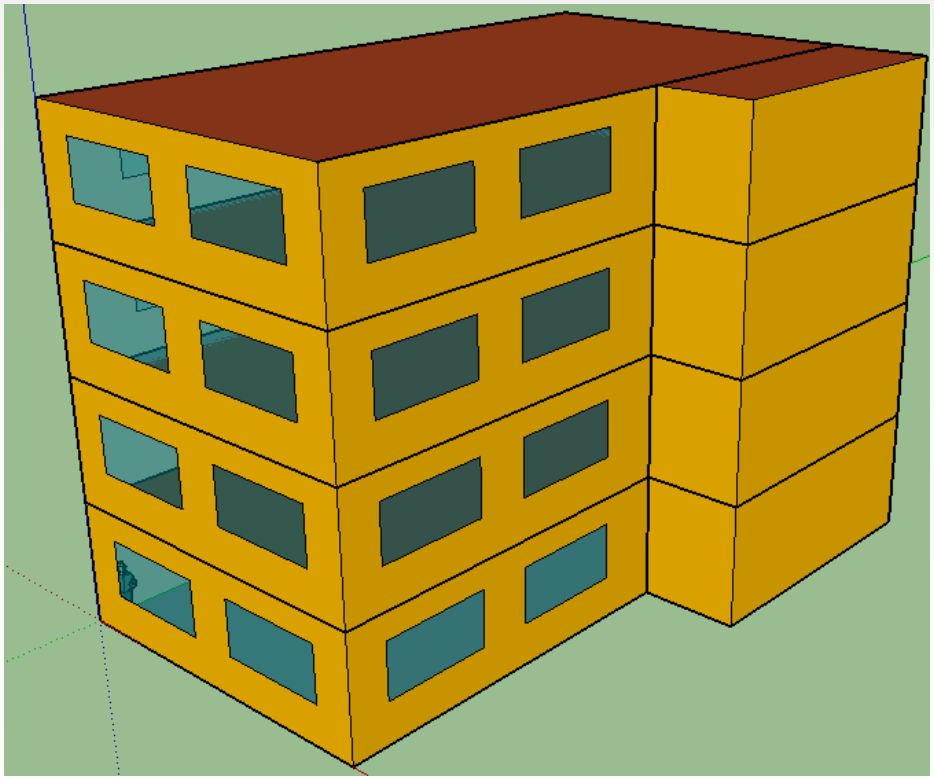
Average Energy Consumption in a Mega city

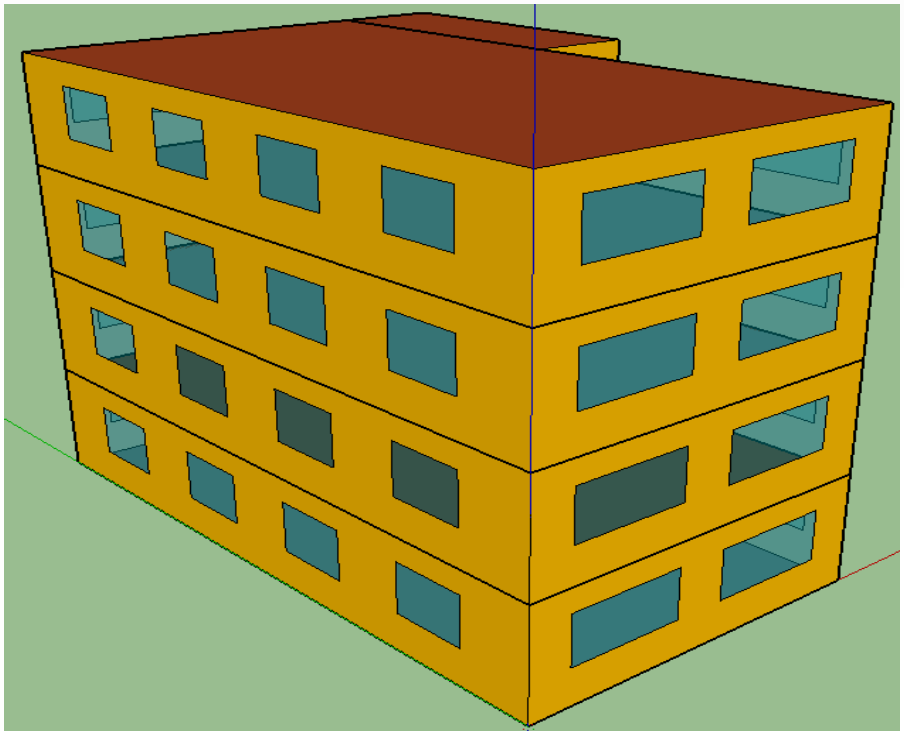
-Example of 17 community center in Seoul, Korea (2014)-



Simulation model for energy conservation (Seokkwan community center)

– East/south view (left) and south/west view (right) –





Remodeling simulation model for energy conservation (Seokkwan community center)

- Building material, area, room load -

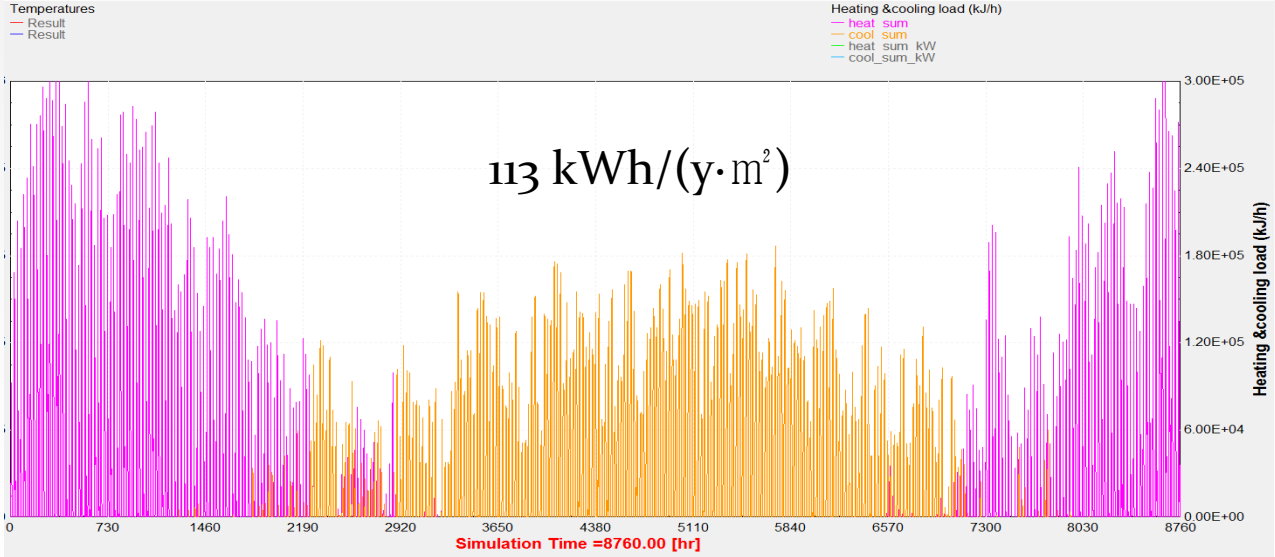
	Thermal transmittance (W/m²k)
Outer wall	0.45
Roof	0.3
Window	5.68 (g값: 0.855)
Curtain wall	0.5

	Area (㎡)
1st floor	170
2nd floor	170
3rd floor	170
4th floor	170
합	680

	Number of people(changeable)	LED	Fluorescent light
1st floor	20(100)	26	14
2nd floor	7(20)	0	30
3rd floor	0(50)	0	30
4th floor	0(50)	0	30
계단	0(60)	0	30
계	22(200)	105	11

Remodeling simulation for energy conservation (Seokkwan community center)

- with room load , all year round-



Room name	Area(m2)	Heating load (kWh)	Cooling load (kWh)
1st floor	170	7,758	11,069
2nd floor	170	8,683	10,128
3rd floor	170	9,167	10,203
4th floor	170	8,072	11,678
Sum	680	33,694	43,083

Remodeling simulation for energy conservation (Seokkwan community center)

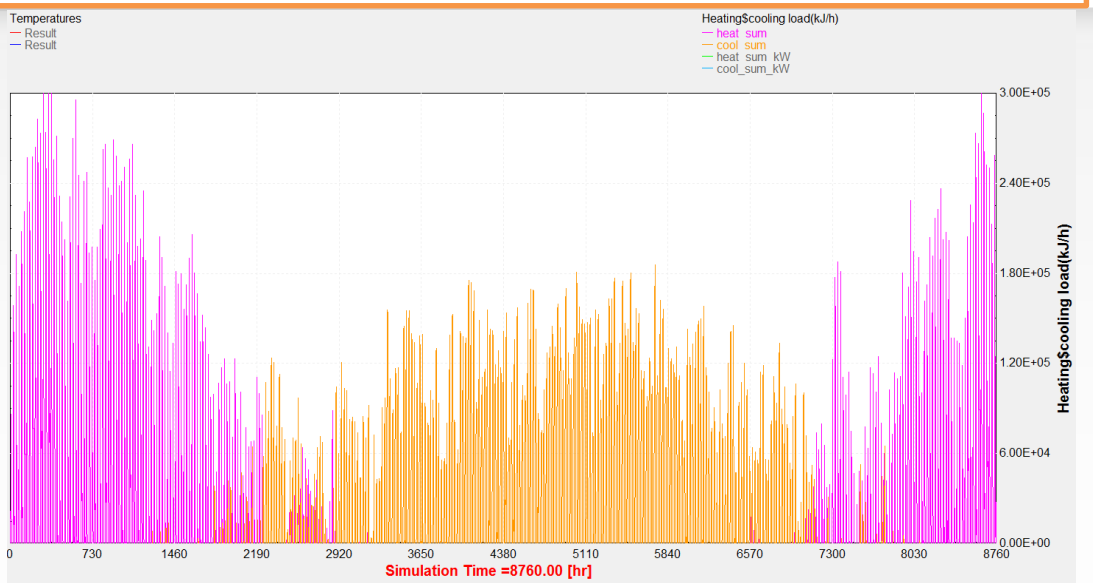
- Increased insulation for outer wall (0.45 -> 0.22)

After double of wall insulation (0.45 -> 0.22)

Heating load:
33,694 kWh -> 30,250 kWh
(10%) decrease

Cooling load:
4,3083 kWh -> 44,944 kWh
(4%) increase

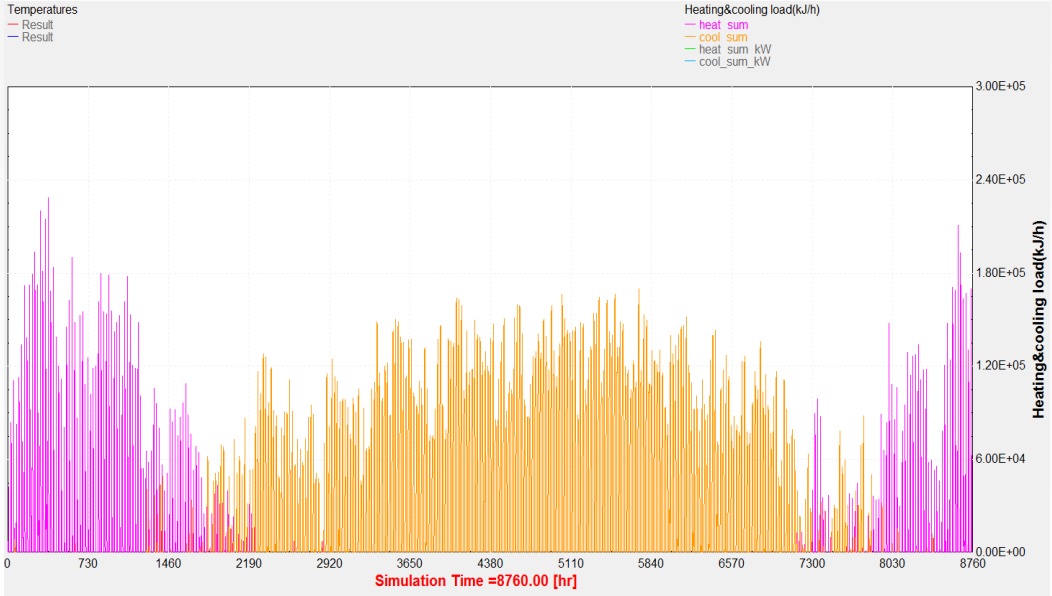
Total: 2% decrease



Room name	Area(m2)	Heating load (kWh)	Cooling load (kWh)
1st floor	170	6,856	11,606
2nd floor	170	7,786	10,592
3rd floor	170	8,294	10,644
4th floor	170	7,314	12,111
Sum	680	30,250	44,944

Remodeling simulation for energy conservation (Seokkwan community center)

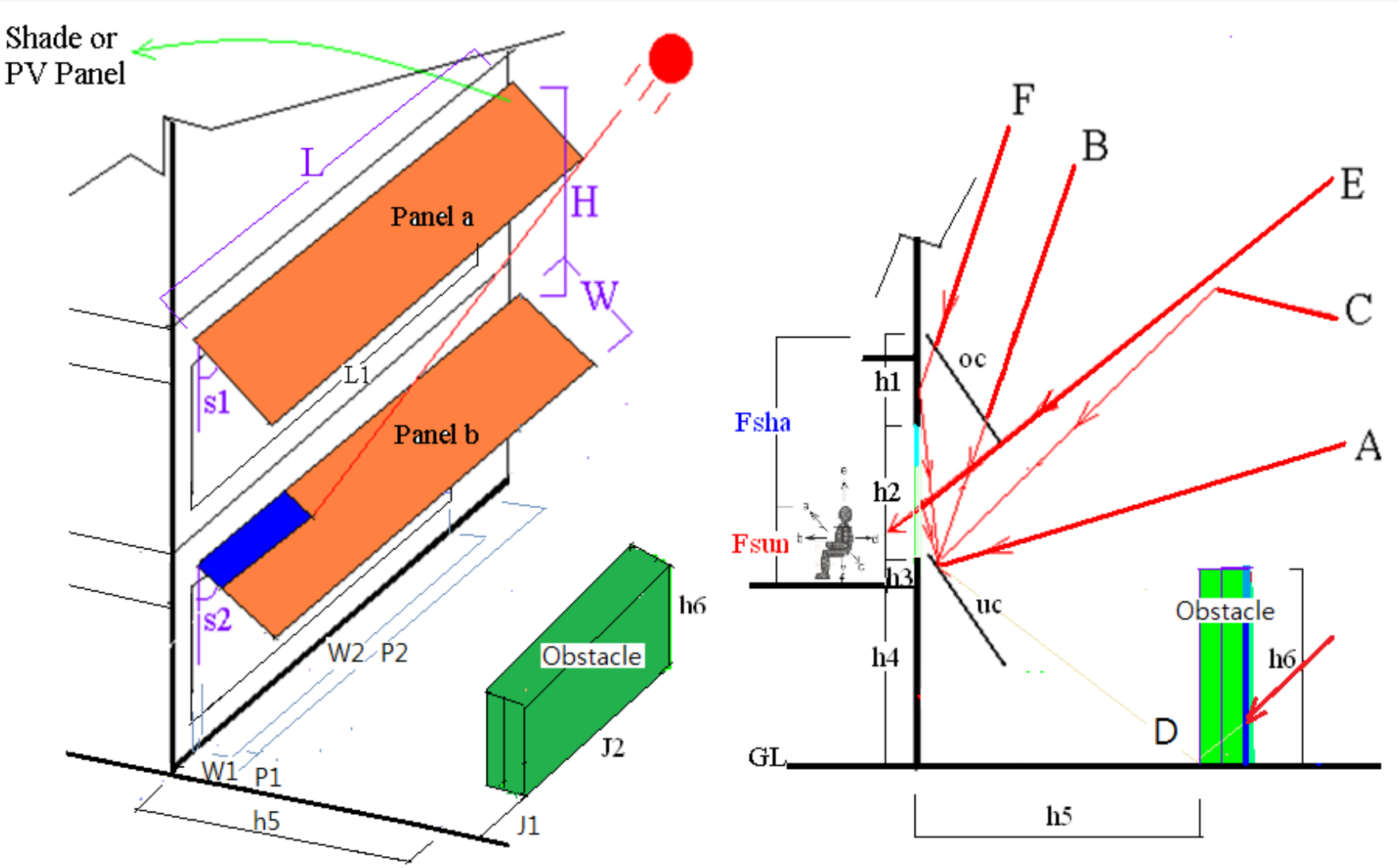
- Change of window (U: 5.68 W/m²K (g: 0.855) -> Kripton gas window (U: 0.86W/m²K (g-Value: 0.598))



Room name	Heating load (kWh)	Cooling load (kWh)
1st floor	2,331	14,956
2nd floor	3,106	13,369
3rd floor	3,625	13,256
4th floor	3,344	14,492
Sum	12,406	56,083

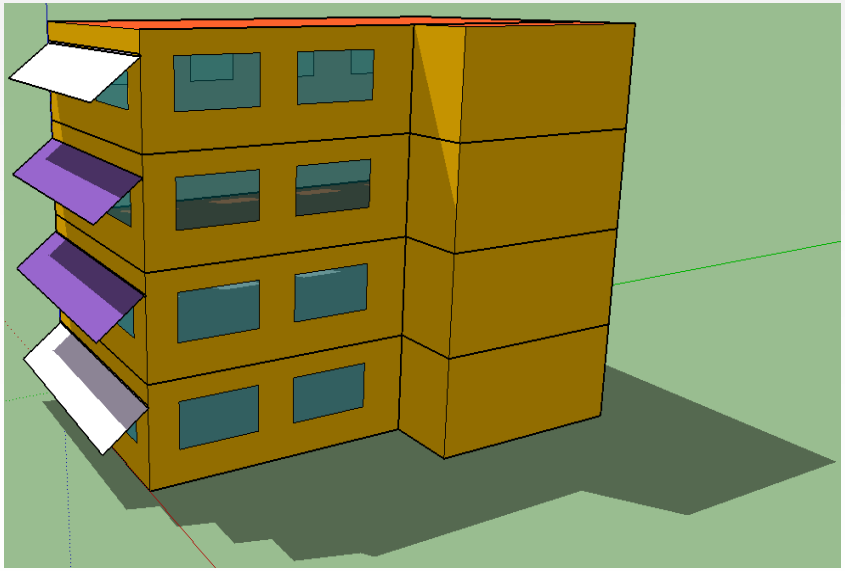
After replace of window:
Heating load: 63% decrease
Cooling load: 23% increase
Total: 10% decrease

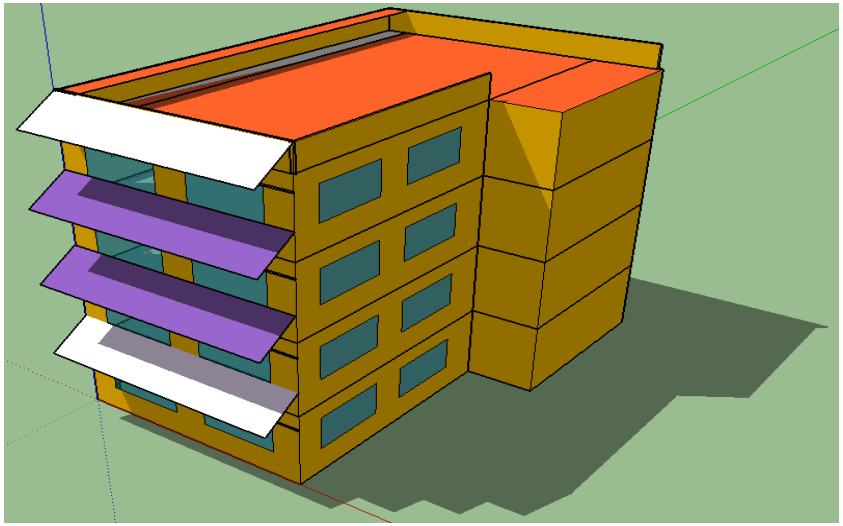
Remodeling application and evaluation by the use of photovoltaic module



Remodeling simulation model for energy conservation (Seokkwan community center)

- with argon gas window and photovoltaic module as a shading device -

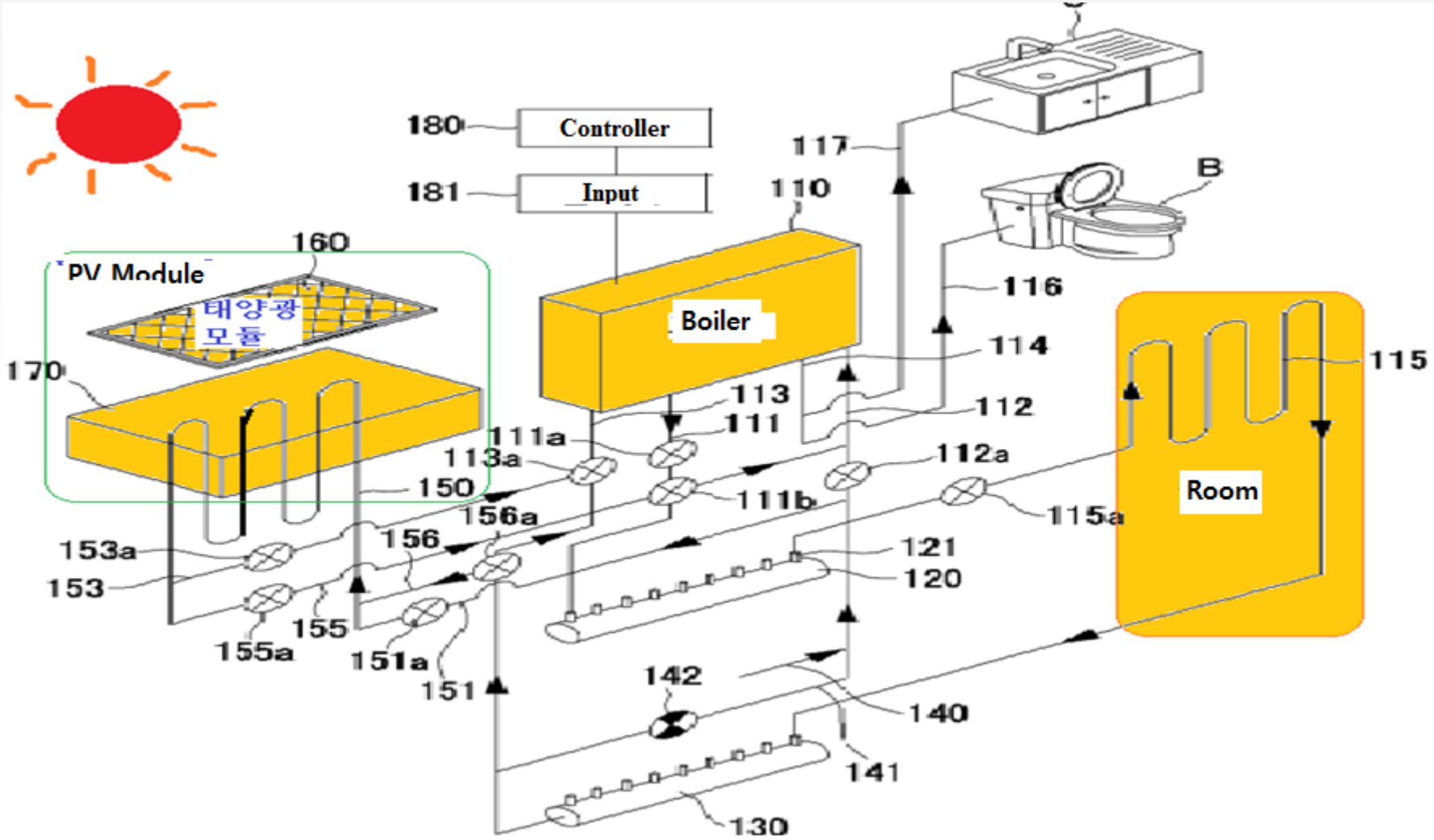




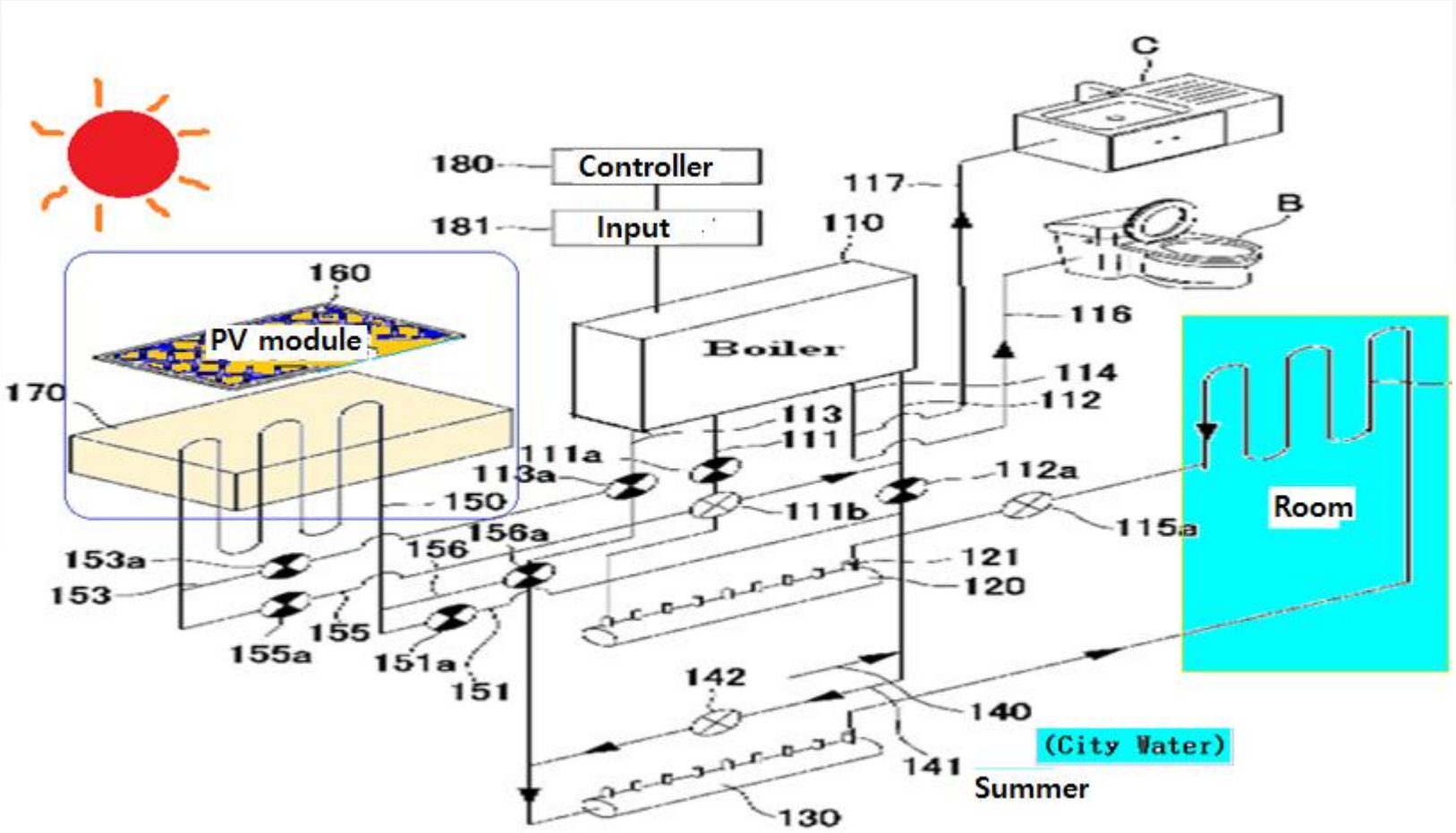
실명	Cooling load(kWh) (shading coef.:1.0)	Cooling load(kWh) (shading coef.:0.7)
1층	9,317	10,331
2층	8,269	8,978
3층	8,992	9,192
4층	8,969	9,533
합계	35,556	38,028

After high insulation window:
Heating load: 33,694 kWh-> 12,406 kWh (63%) decrease, with outer shading: cooling load 43,083kWh ->38,028 kWh(shading coef. :0.7), 35,556 kWh (shading coef.: 1) decrease
Therefore,
Totally 76,777 kWh-> 47,962 kWh(shading coef: 1), 50,434 kWh(shading coef.:0.7), respectively 38% and 34% energy conservation

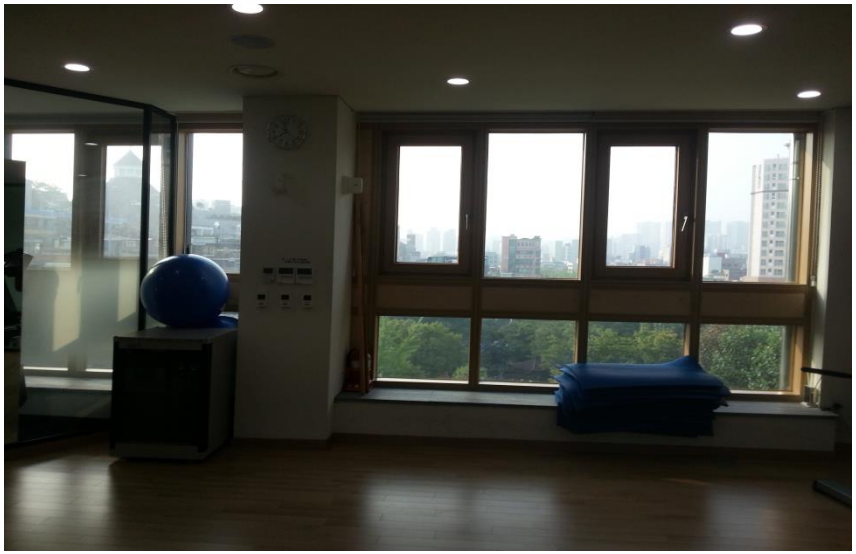
Ecological convergence of photovoltaic system and cooling&heating system[Heating period]



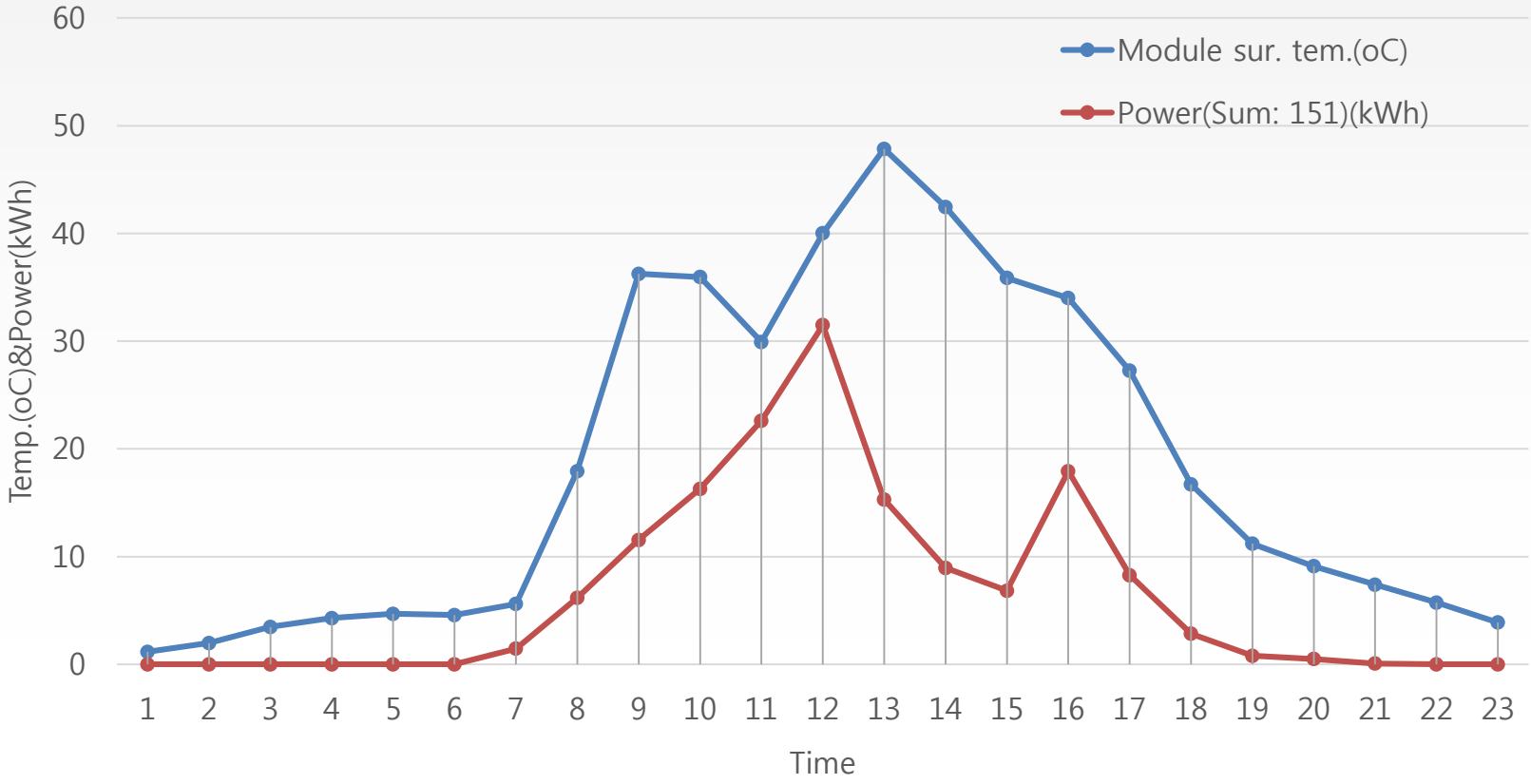
Ecological convergence of photovoltaic system and cooling&heating system[cooling period]



Community center integrated photovoltaic (Anam-Dong, PV on roof top, inside)



Ecological convergence of photovoltaic system and cooling&heating system[Photovoltaic]



Photovoltaic system as a shading device in conjunction with Heating & cooling system
PV power: 134 kWh -> 151 kWh (11.3% increase)
Payback period: 5 year

Evaluation Standard of Solar Architecture

	Evaluation Item		Remark	Point
Solar Radiation (1 Item: 20 %)	**Effective Solar Irradiance**		Effective Solar Irradiance Factor	20
Energy (3 Items: 20%)	Energy Conservation through Natural Ventilation		Natural Ventilation: 3	3
	Heating & Cooling Load Reduction	Transparent Envelope	Total Energy Elimination Factor:3	11
			Total Energy Transmittance Factor:3	
		Opaque Envelope	Thermal Conductance: 5	
	Consideration for Power Generation Improvement		Shaded Area on Module: 3	6
			Module Surface Temperature: 3	
Aesthetic View (1 Item: 10%)	•Harmony with Architecture or Finish Envelope		Harmony with Architecture	5
			Finish Material	5

Evaluation Standard of Solar Architecture

	Evaluation Item		Remark	Point
Indoor Environmental Quality (3 Items: 15%)	Acoustic Env.	Puffer against outside noise		5
	Thermal (Air) Env.	Thermal Comfort	Operative Temperature	3
		Air Flow	Balanced Airflow	2
	Lighting Env.	Sunshine Hour in Room		3
		Glare		2
Maintenance (6 Items: 18%)	Building Energy Management System		Intelligent Building Management System	3
	Manual for Maintenance			3
	Testing, Adjusting, and Balancing			2
	Monitoring		Smart Grid (Sensors)	4
	Continuity of Effective Solar Irradiance			3
	Clean Easiness for Module Surface			3

Evaluation Standard of Solar Architecture

	Evaluation Item	Remark	Point
Practical Use of Structure (2 Items: 10%)	Application for a New Building		3
	Application for a Remodeling		3
Safety (2 Items: 4%)	Fire Resistance		2
	Impact Intensity		2
Environmental Friendliness (1 Item: 10%)	Co2 Evaluation through Life Cycle Analysis of a System	LCCo2	7
8 Items	**19 Evaluation Items**	1st Grade: 90 2nd Grade: 80 3rd Grade: 70	**100 %**

Evaluation standard for remodeling for energy conservation and green house gas mitigation

Category	Evaluation Factor		Remarks	Score
Solar Radiation (1 Item: 20 %)	Effective Solar Irradiance		Effective Solar Irradiance Factor	20
Energy (3 Items: 20%)	Energy Conservation through Natural Ventilation		Natural Ventilation	3
	Heating & Cooling Load Reduction	Transparent Envelope	Total Energy Elimination Factor : 5	12
			Total Energy Transmittance Factor: 5	
		Opaque Envelope	Thermal Conductance: 2	
	Consideration for Power Generation Improvement		No shaded Area on Module: 3	6
			Convergence idea: 3	
Aesthetic View (1 Item: 10%)	Harmony with Architecture or Finish Envelope		Harmony with Architecture : 5	10
			Finish Material : 5	
Indoor Environmental Quality (3 Items: 15%)	Acoustic Env.	Puffer against outside noise	5	5
	Thermal (Air) Env.	Thermal Comfort	Operative Temperature : 3	3
		Air Flow	Balanced Airflow	2
	Lighting Env.	Sunshine Hour in Room		2
		Glare		3

Evaluation standard for remodeling for energy conservation and green house gas mitigation

Maintenance (4 Items: 17%)	Building Energy Management System	Intelligent Building Management System	5
	Monitoring		5
	Continuity of Effective Solar Irradiance		4
	Cleaning for Module Surface	Smart Grid (Sensors)	3
Practical Use of Structure (2Items: 6%)	Application for a New Building		3
	Application for a Remodeling		3
Safety (2 Items: 4%)	Fire Resistance		2
	Impact Intensity		2
Environmental Friendliness (1 Item: 7%)	CO_2 Evaluation through Life Cycle Analysis of a System	$LCCO_2$	7
8 Categories	**17 Evaluation Factors**	1st Grade: 90, 2nd Grade: 80, 3rd Grade: 70	100

Results and discussion

1. -Need to make optimal use a natural energy by the passive intelligence concepts,

2. - additionally ecological use through strategical fusion with photovoltaic system,

3. -worldwide Dissemination of Solar Architecture or village harmony with regional weather, culture and tradition, and

4. -problem solving by engineering science from the ecological point of view.

Results and discussion

5

The ecological application of photovoltaic module,
which can get about 11% more power generation rather than simple application and conserve building energy in an ecological way, is very effective.

6

-Photovoltaic system as an exterior shading or double envelope with high insulation window and wall could be a good example for at least 50% energy conservation and 40% green house gas mitigation to a conventional building besides PV power generation.

Thank you for your attention!