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# Costruire edifici ad Energia Zero

**La prima casa Off-grid nel deserto di Dubai**

**SPEAKER**  
**prof. Giuseppe Franchini**

**LOCATION**  
**IIS Mosè Bianchi, Monza**

# Red Sea City project

<https://www.theredsea.sa/en>



The Red Sea  
Development  
Company

## The Destination

The Red Sea Project will be an exquisite sanctuary offering indulgent experiences, seamlessly customized to the unique needs of each visitor. Extending over 28,000 square kilometers on Saudi Arabia's Red Sea coast, the destination will offer a uniquely diverse range of experiences, from island getaways to resort holidays, mountain retreats and desert adventures.

The destination is rich in culture and tradition. Visitors will have a wealth of opportunities to explore the history of the region and experience first-hand the fabled hospitality and fascinating culture of Saudi Arabia.

A special emphasis on environmental sustainability will ensure that the natural beauty of the destination will engage and excite visitors for generations to come.



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# Red Sea City project

<https://www.theredsea.sa/en>



VISION

## A principled approach

We are pursuing a policy of 100 per cent renewable energy at the destination, with the ultimate objective of generating and storing energy exclusively from using renewable sources.

We plan to implement a range of policies including zero waste-to-landfill, 100 percent carbon neutrality and a total ban on single use plastics. Where the technology currently exists to achieve this, we will implement it. Where it doesn't exist today, we will seek to develop it.

PRINCIPLES

- 100 percent renewable energy 24 hours a day
- Zero single use plastics
- Net positive conservation impact
- Zero discharge to the sea
- 100 percent carbon neutrality

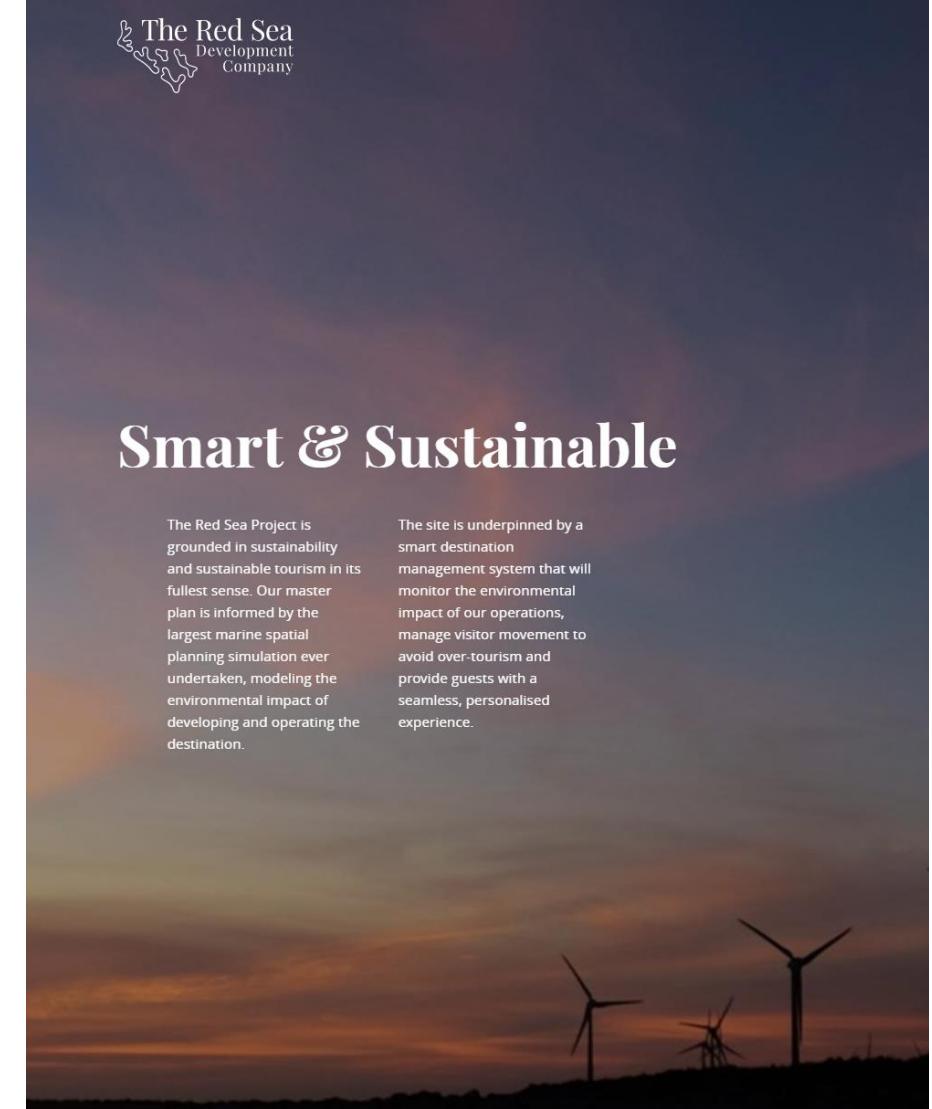
ACHIEVEMENTS



## Smart & Sustainable

The Red Sea Project is grounded in sustainability and sustainable tourism in its fullest sense. Our master plan is informed by the largest marine spatial planning simulation ever undertaken, modeling the environmental impact of developing and operating the destination.

The site is underpinned by a smart destination management system that will monitor the environmental impact of our operations, manage visitor movement to avoid over-tourism and provide guests with a seamless, personalised experience.

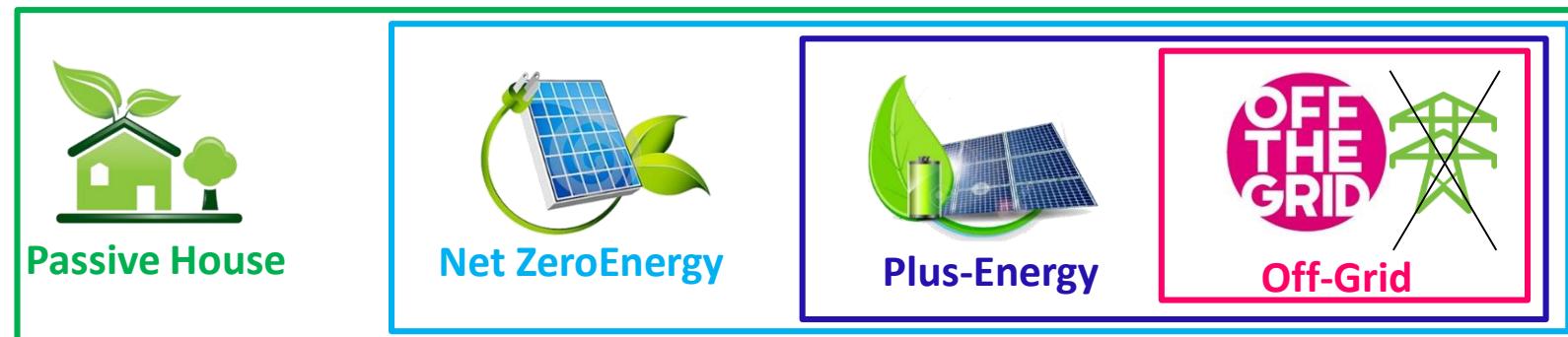
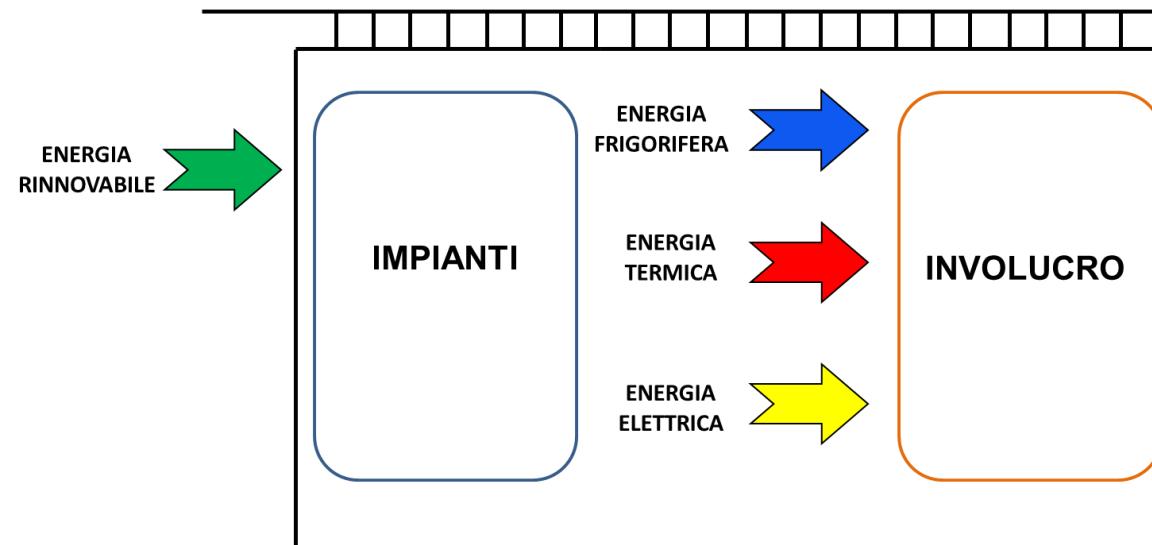


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# Standard energetici per gli edifici

Da «EDIFICIO = luogo di consumo» a «sistema autosufficiente»



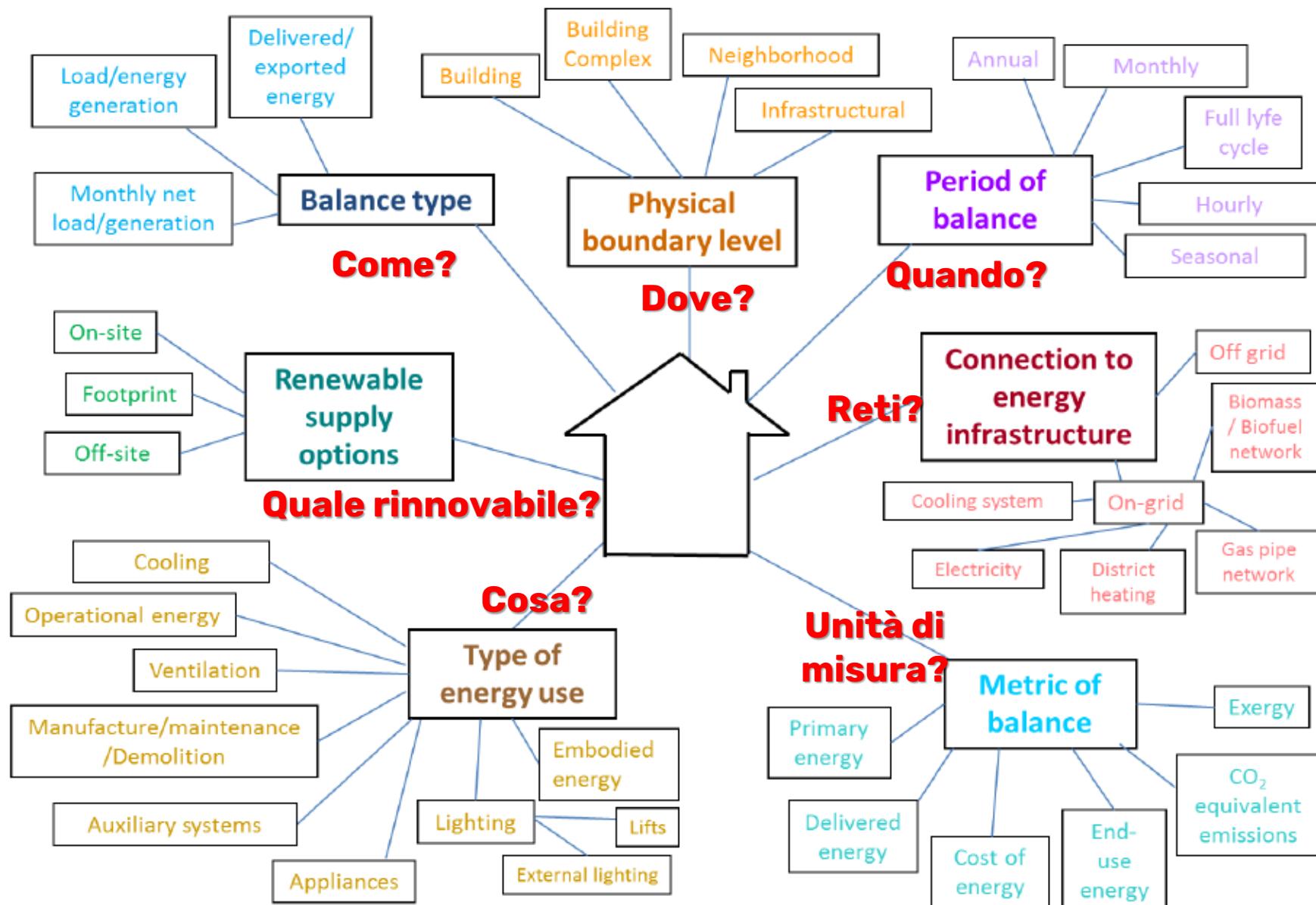
# Standard energetici per gli edifici

**Low Energy House (Edificio a basso consumo)**: edificio con prestazioni energetiche sensibilmente migliori rispetto a quelle minime previste dalle regolamentazioni vigenti.

**Passivhaus (Casa passiva)**: edificio che copre la maggior parte del suo fabbisogno di energia per riscaldamento e raffrescamento ambientale interno ricorrendo a dispositivi passivi, rispettando i criteri definiti dal Passivhaus Institut di Darmstadt (Germania).

**ZEB - Zero Energy Building (Edificio a Energia Zero)**: edificio in cui il consumo totale annuale di energia (primaria) è uguale alla produzione in loco (di energia primaria)"





# Standard energetici per gli edifici

**nZEB – Nearly Zero Energy Building (Edificio a Energia Quasi-Zero):** edificio dal fabbisogno energetico molto basso o quasi nullo, coperto in misura molto significativa da energia da fonti rinnovabili

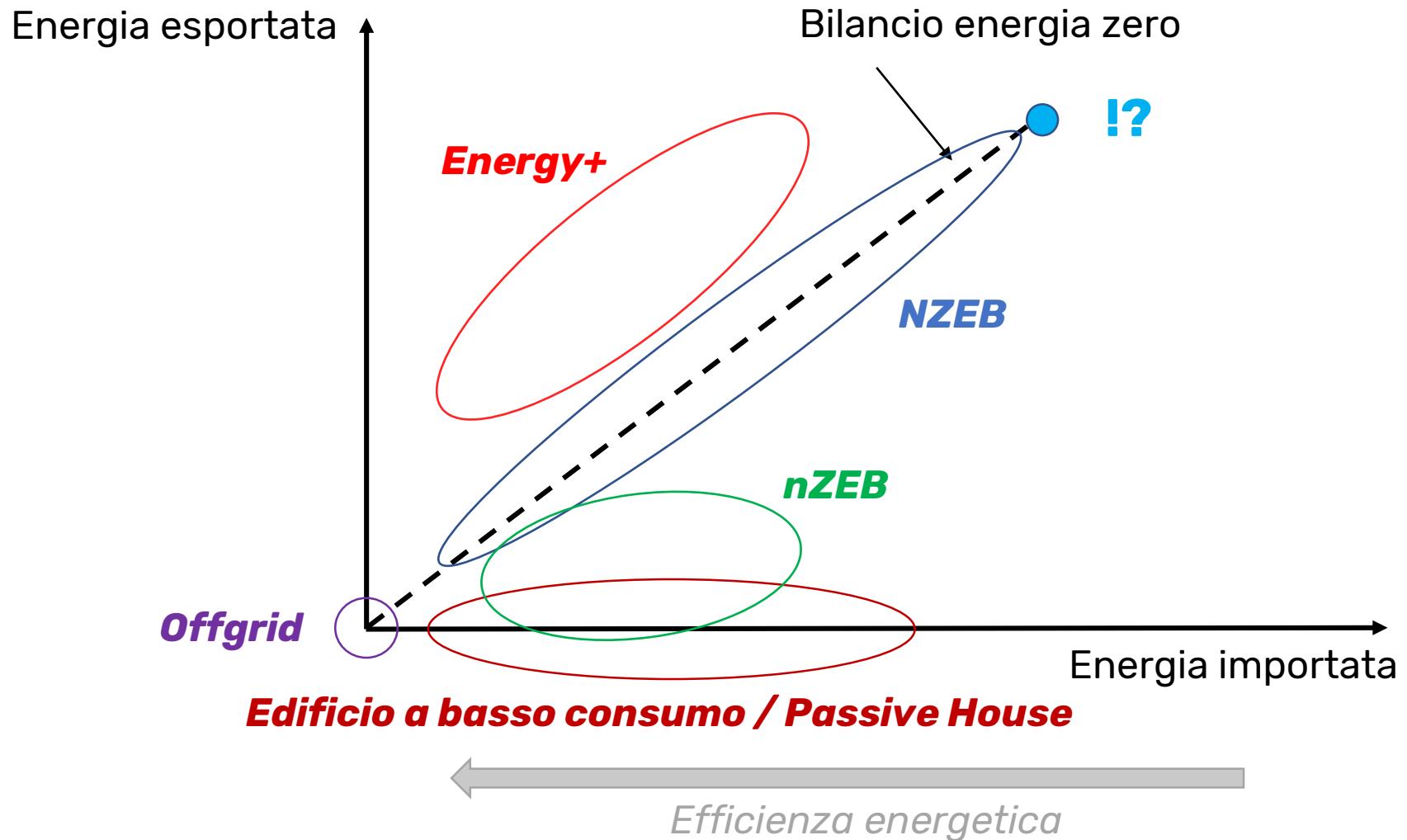
**NZEB – Net Zero Energy Building (Edificio a Energia Netta Zero):** edificio con bilancio annuale nulla di energia primaria (perfetta compensazione tra produzione e consumo)

**Energy+ Building o Plus Energy Building (Edificio Energy+):** edificio in cui la produzione totale annuale supera il consumo di energia primaria

**Autonomous Building / Off-the-Grid Building (Edificio Autonomo):** edificio in grado di garantire l'autosufficienza energetica 24/7 senza interconnessioni con reti

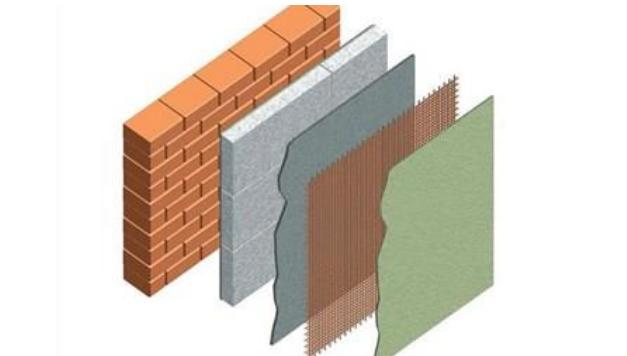
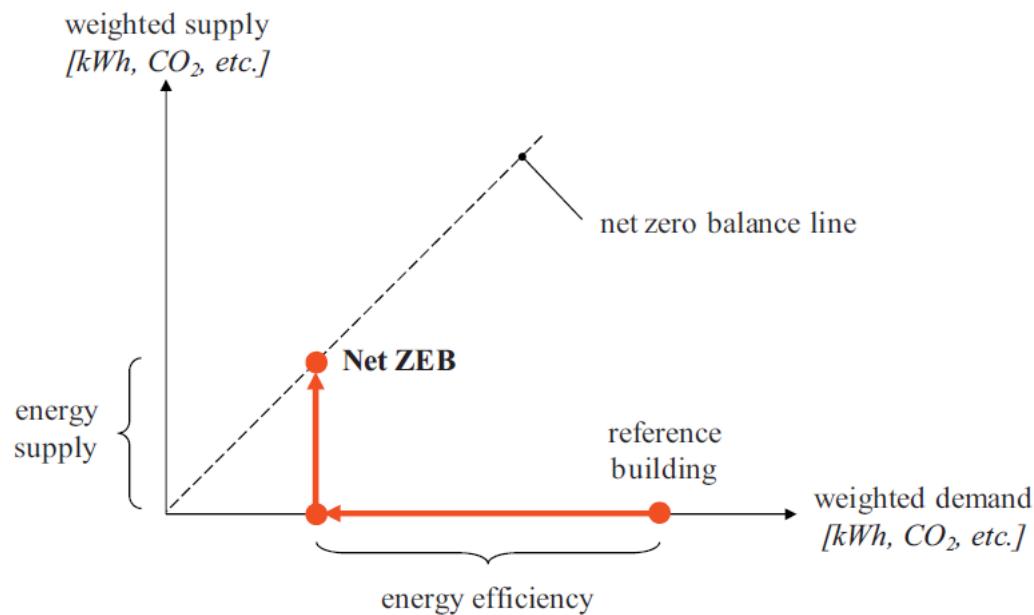


# Standard energetici per gli edifici

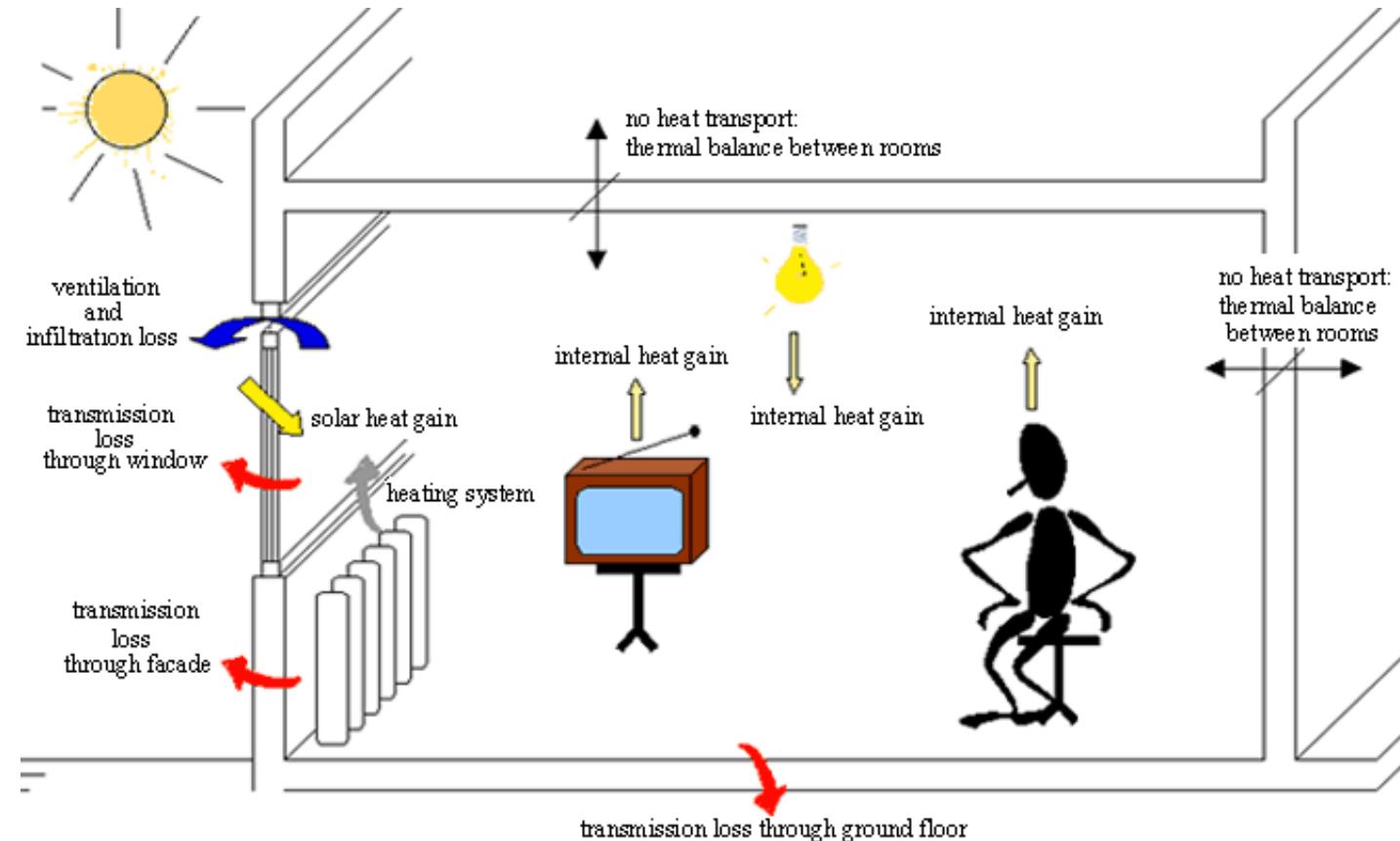


# Criteri progettuali per un edificio ad energia zero

- ✓ L'impiantistica (fase di **generazione**) assume un ruolo fondamentale...
- ✓ ...ma la prestazione dell'**invólucro** rimane imprescindibile!



# Criteri progettuali per un edificio ad energia zero



✓ L'**utente** dell'edificio diventa attore determinante

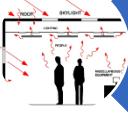


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# Criteri progettuali per un edificio ad energia zero

- ✓ Singola **stagione termica** (solo *heating*, solo *cooling*) o doppia stagione termica (***heating & cooling***)?

	<b>heating</b>	<b>cooling</b>
 Apporti solari	positivo	negativo
 Colore chiaro	negativo	positivo
 Ombreggiamenti	negativo	positivo
 Carichi interni	positivo	negativo

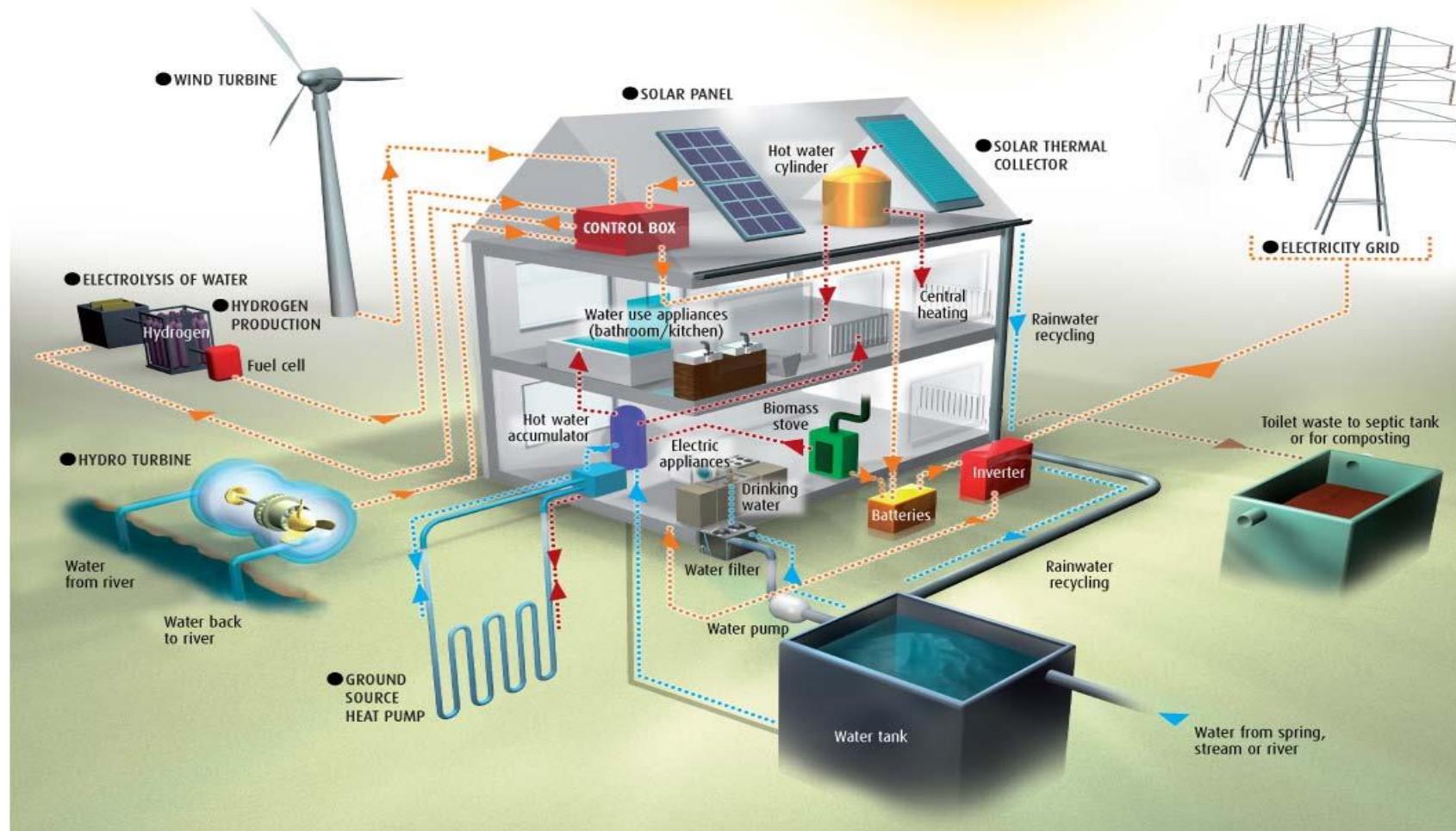


# GOING IT ALONE

With enough renewable technologies you will only need the grid to help pay your bills

Electricity  
Heat

Water  
Waste



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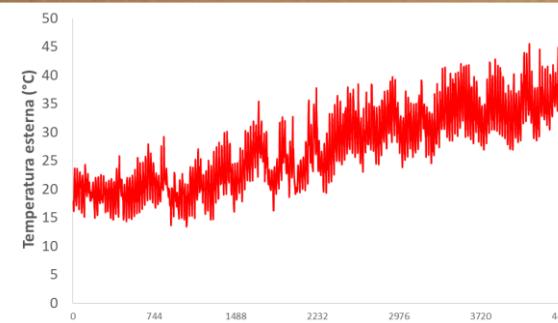
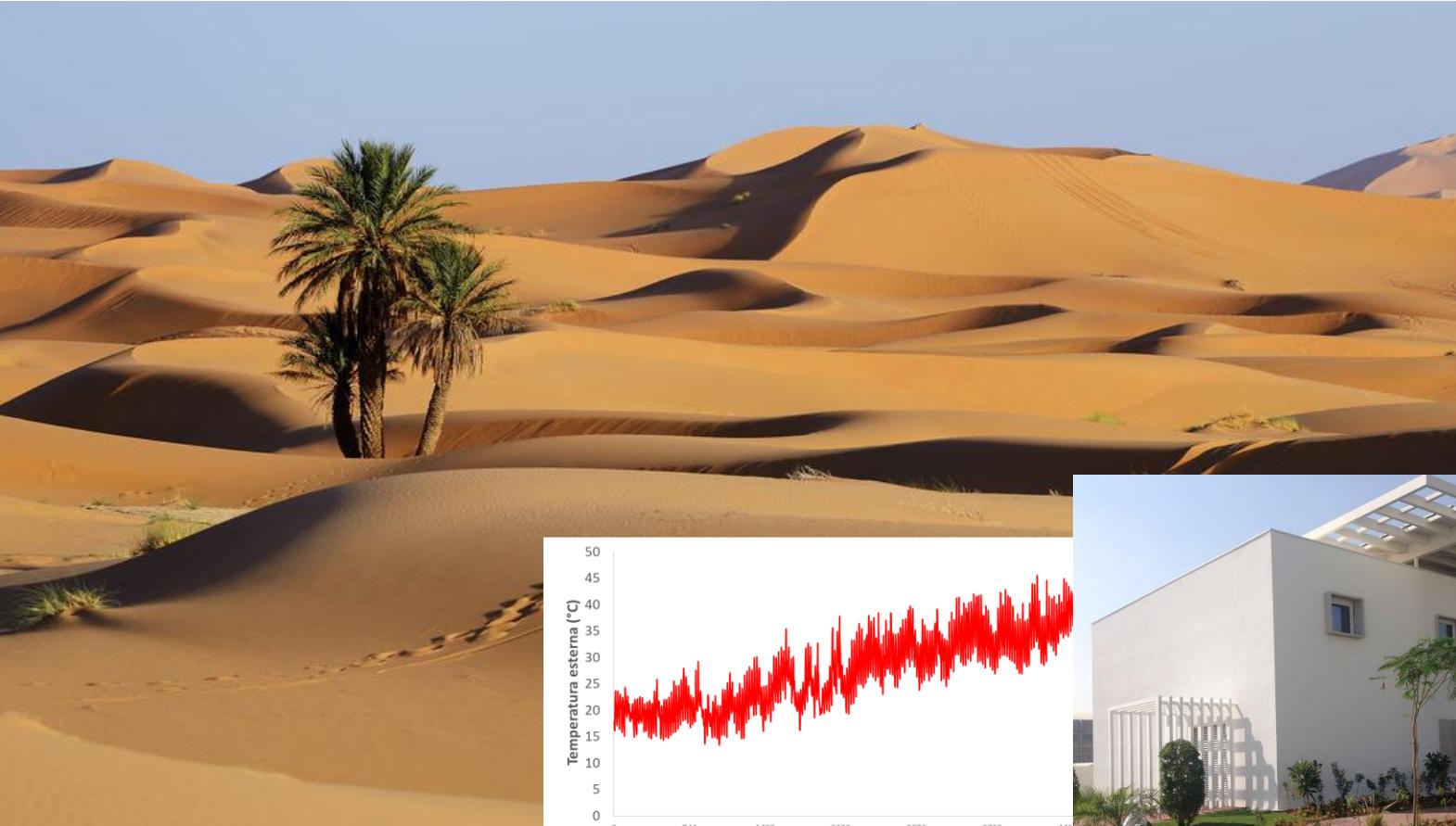
imagination at work



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# La sfida: edificio off-grid nel deserto



$T_{AMB} > 45-50^{\circ}\text{C}$  per settimane/mesi

$T_{INT} = 24^{\circ}\text{C}$  (comfort ideale utilizzando unicamente energia solare)



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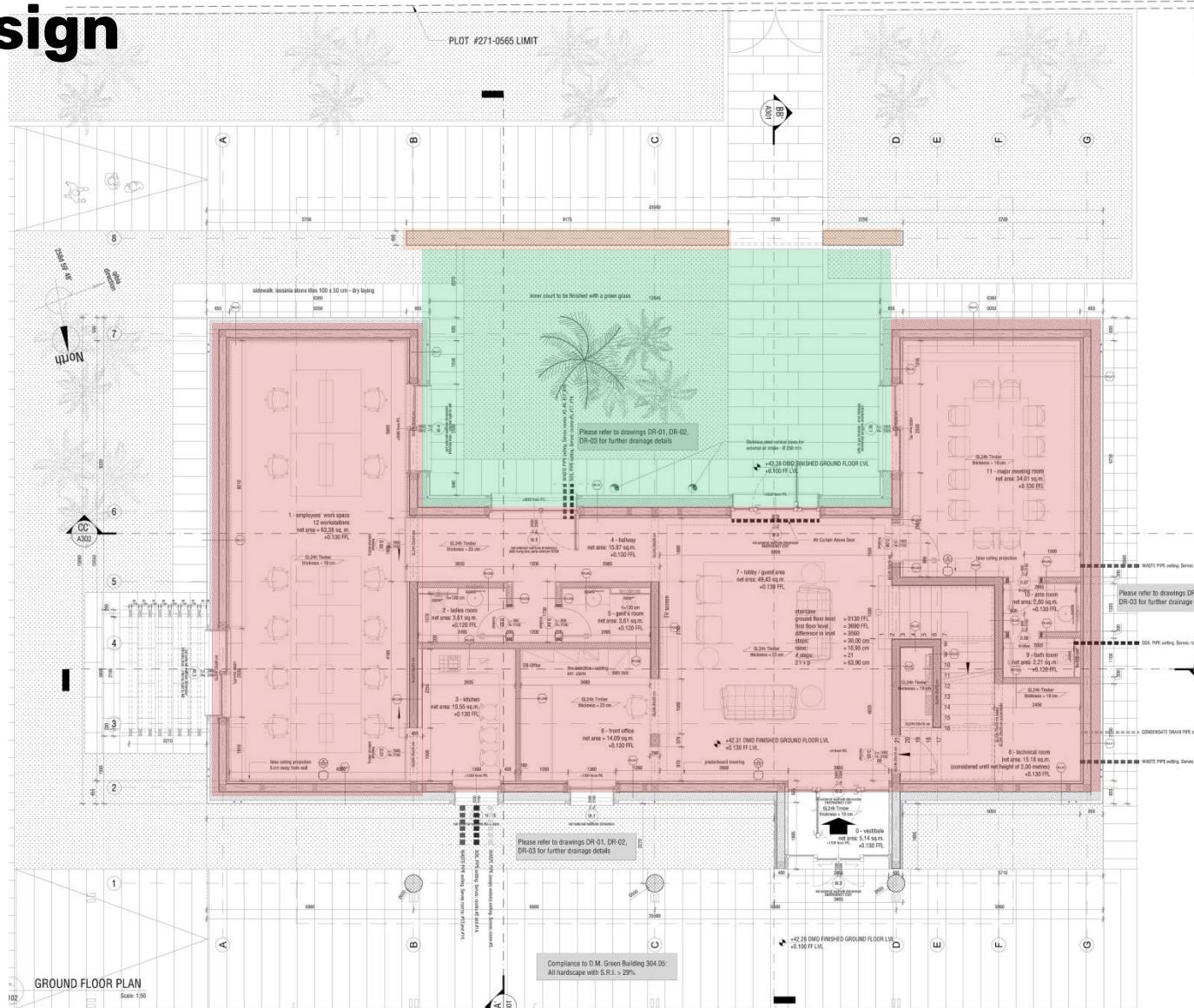
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# Building design



# Building design

PHOTOVOLTAIC SYSTEM LEVEL  
+8.555 FF LVL  
FLASHING  
+7.565 FF LVL  
ROOF LEVEL  
+7.400 FF LVL

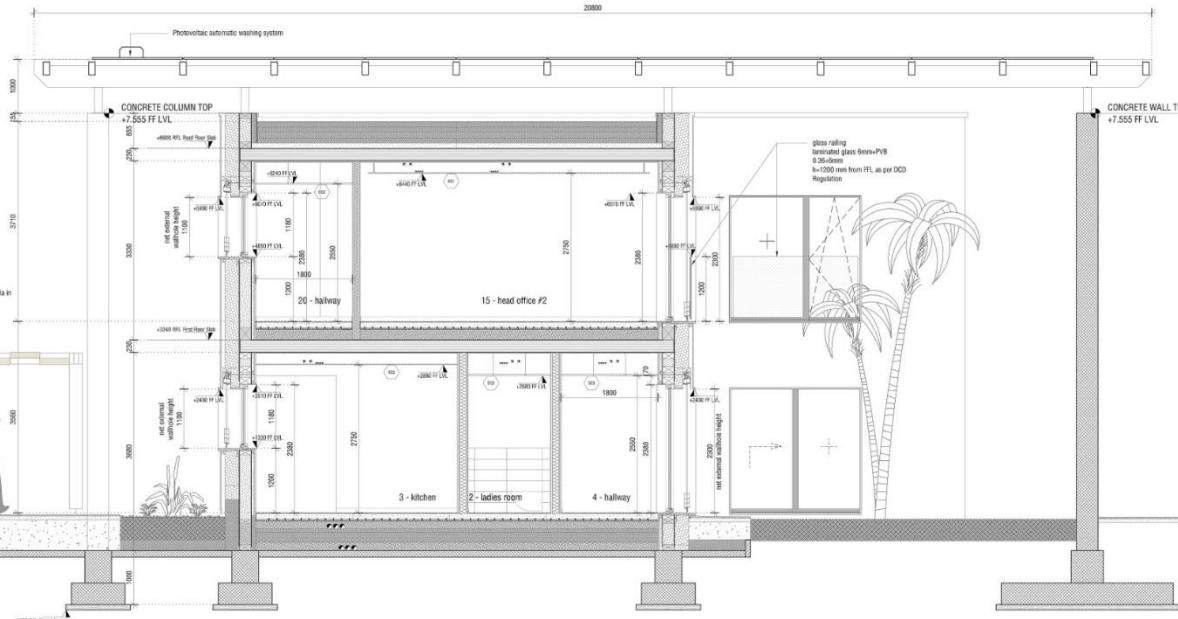
FIRST FLOOR LEVEL  
+3.690 FF LVL

GROUND FLOOR LEVEL  
+0.130 FF LVL + +2.31 DMD FF LVL

CROSS SECTION AA  
A-301

Scale 1:50

-1010 MM External



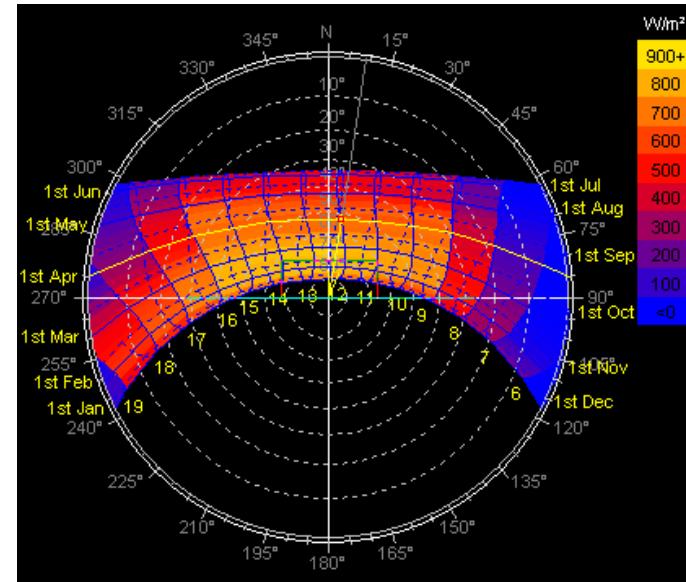
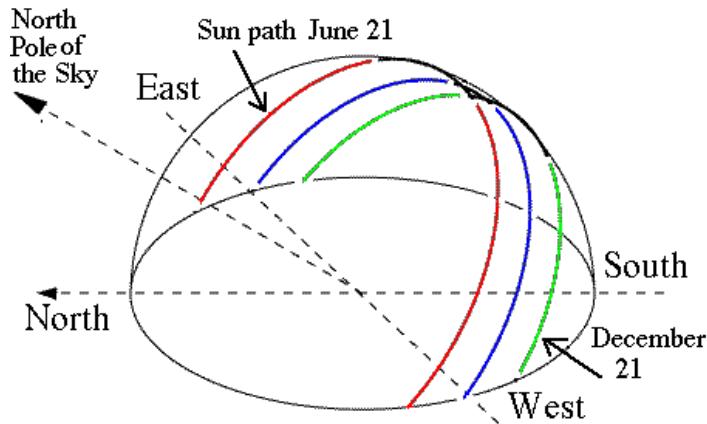
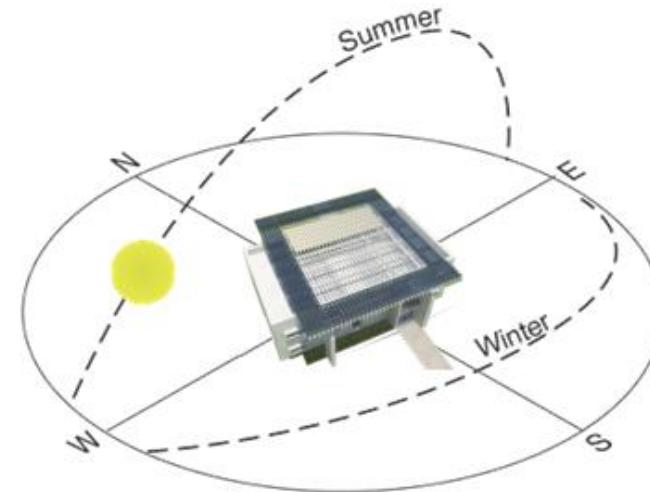
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## Studio dell'orientamento

- Traiettorie solari
- Corretta esposizione superfici vetrate
- Calcolo apporti solari
- Massimizzare produzione PV

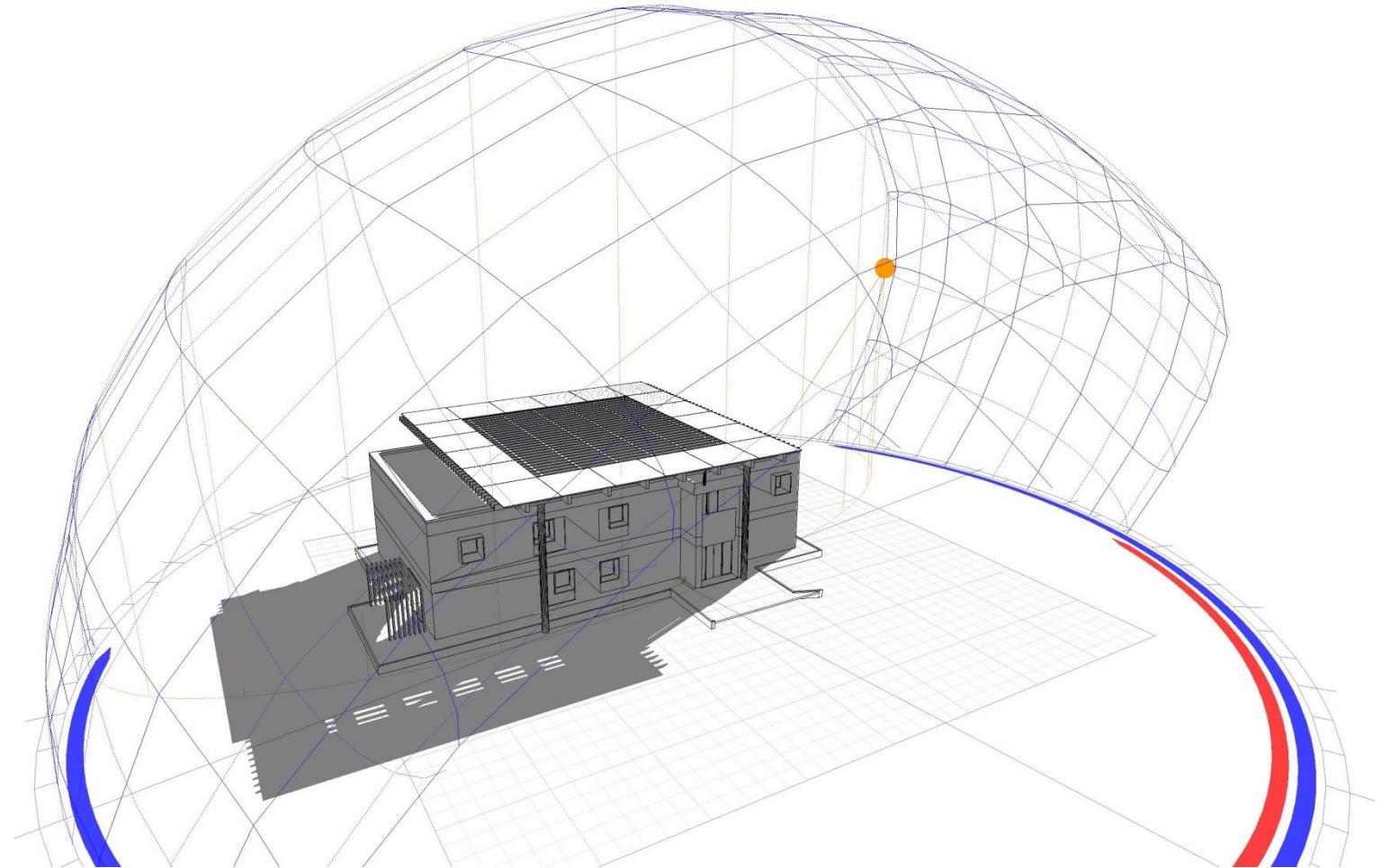


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# Building design

SHADING - DAILY  
Summer Solstice:  
June, 21th — 8:00



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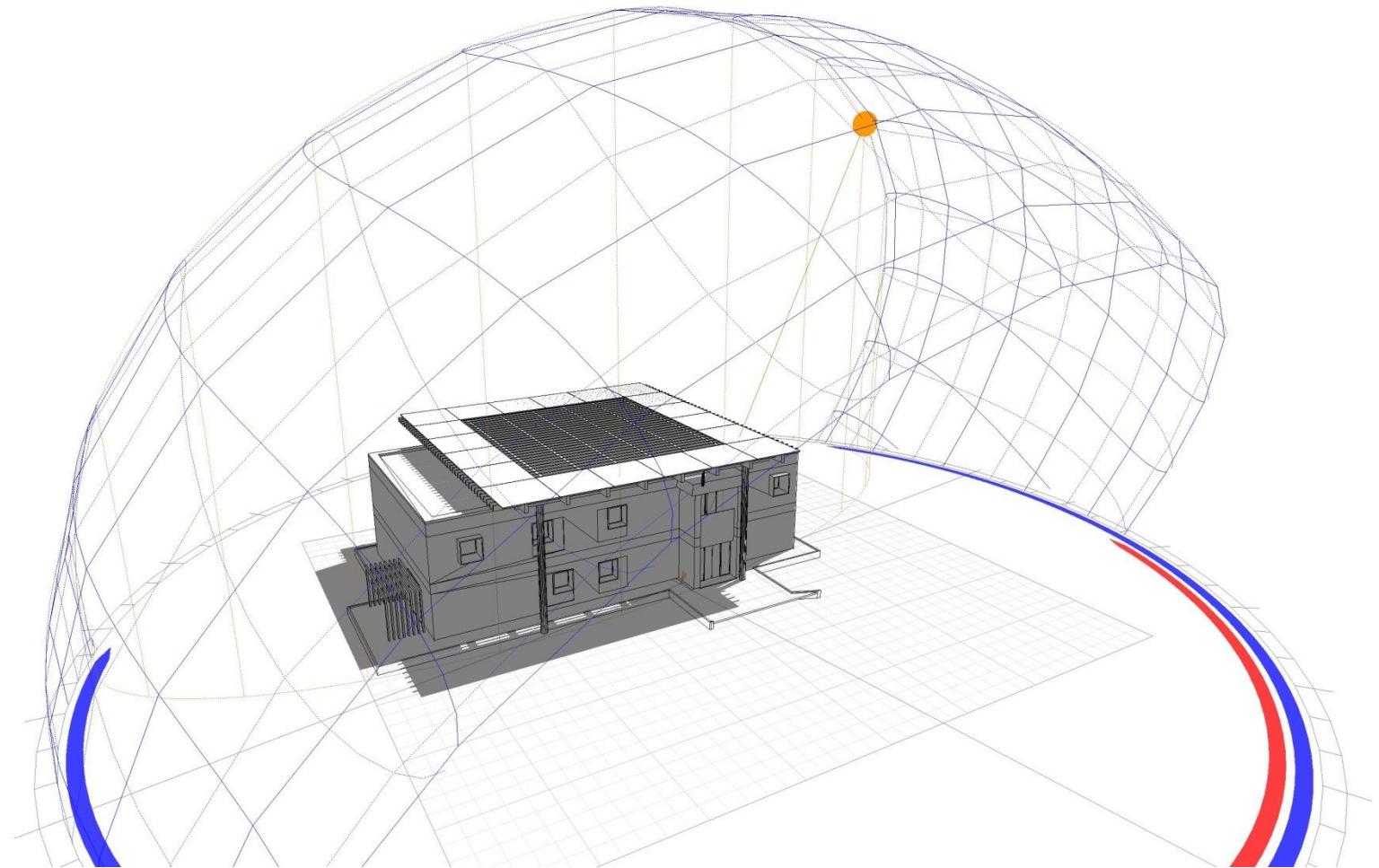
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# Building design

SHADING - DAILY

Summer Solstice:

June, 21th — 10:00



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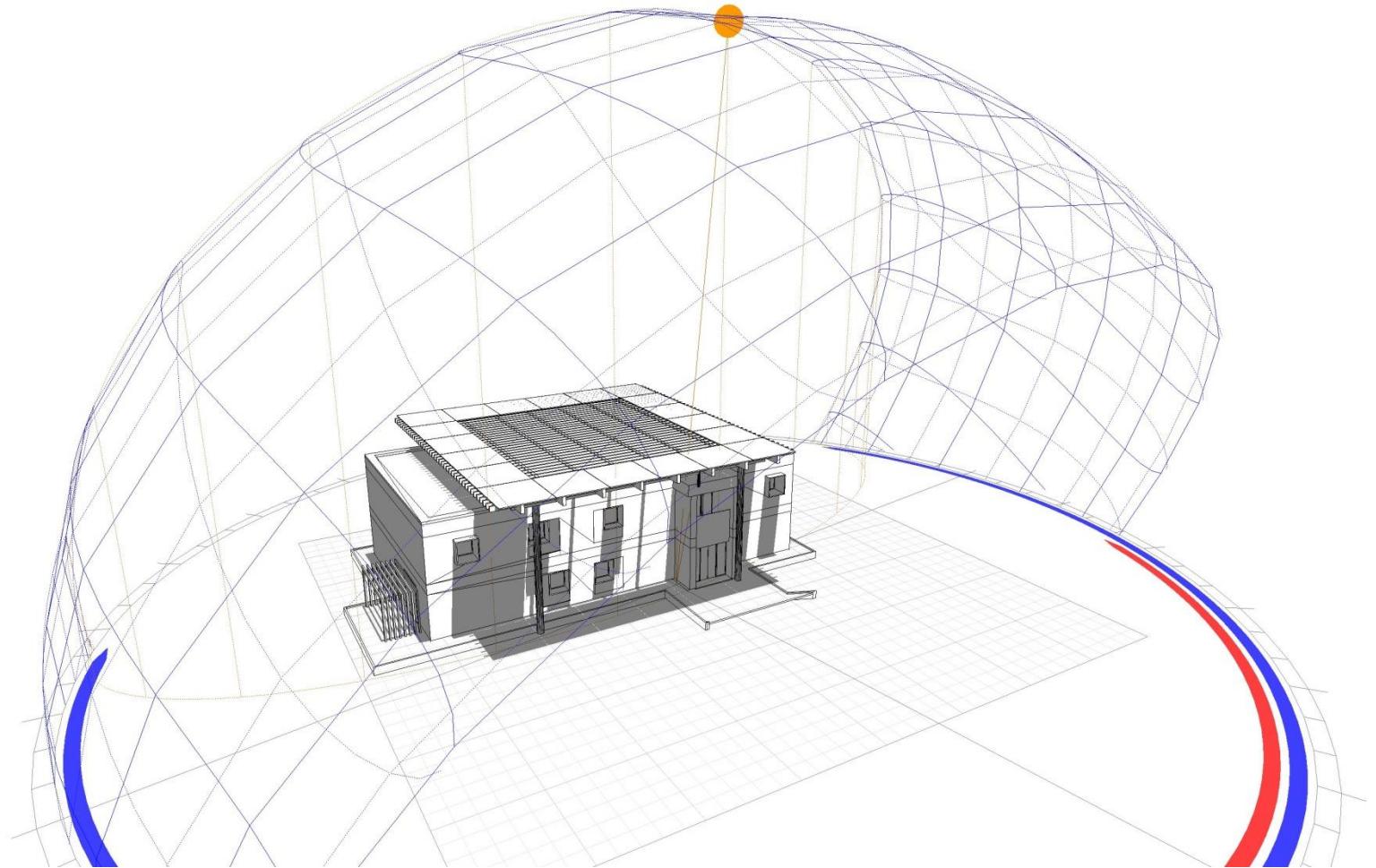
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# Building design

SHADING - DAILY

Summer Solstice:

June, 21th — 12:00



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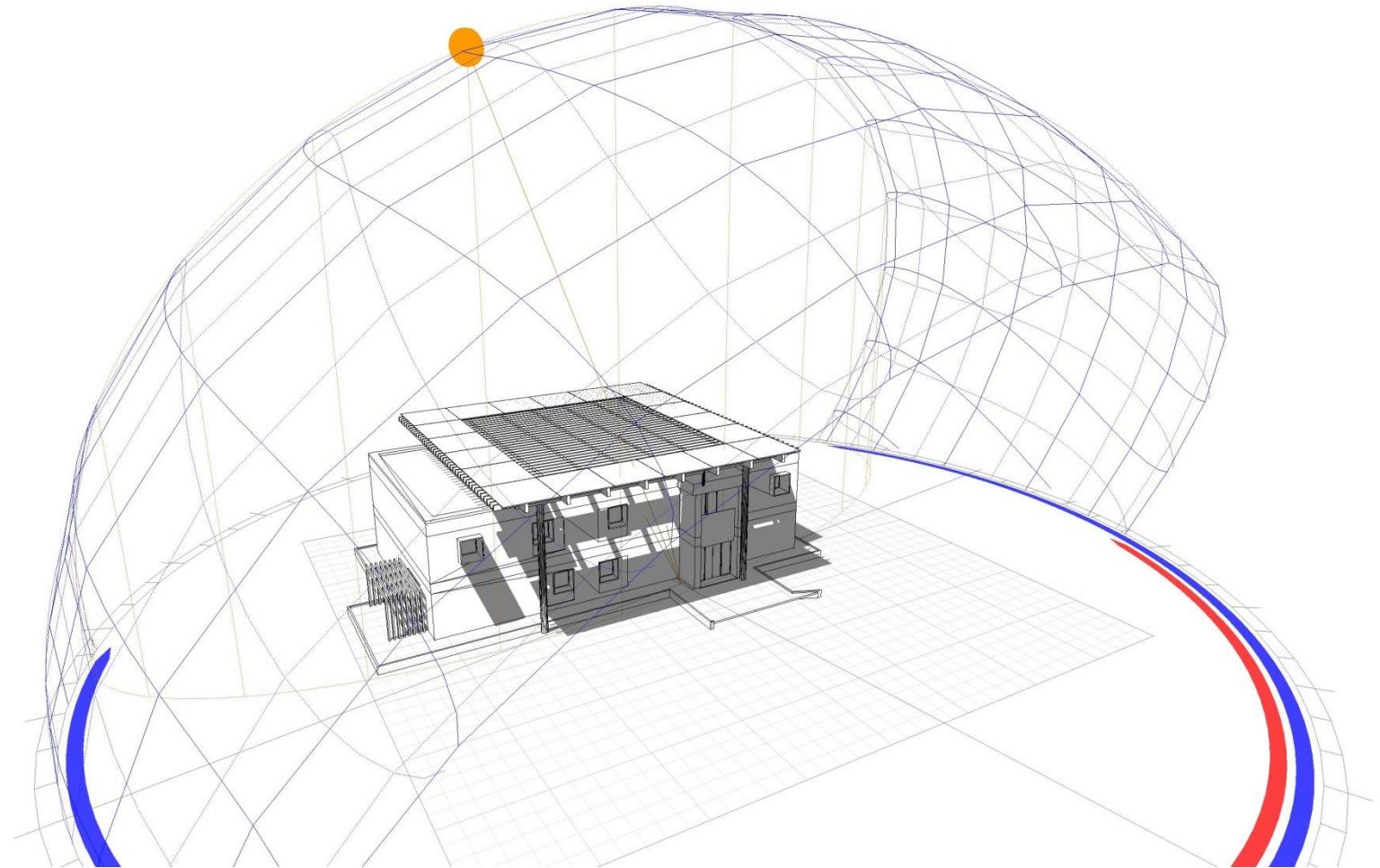
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# Building design

SHADING - DAILY

Summer Solstice:

June, 21th — 14:00



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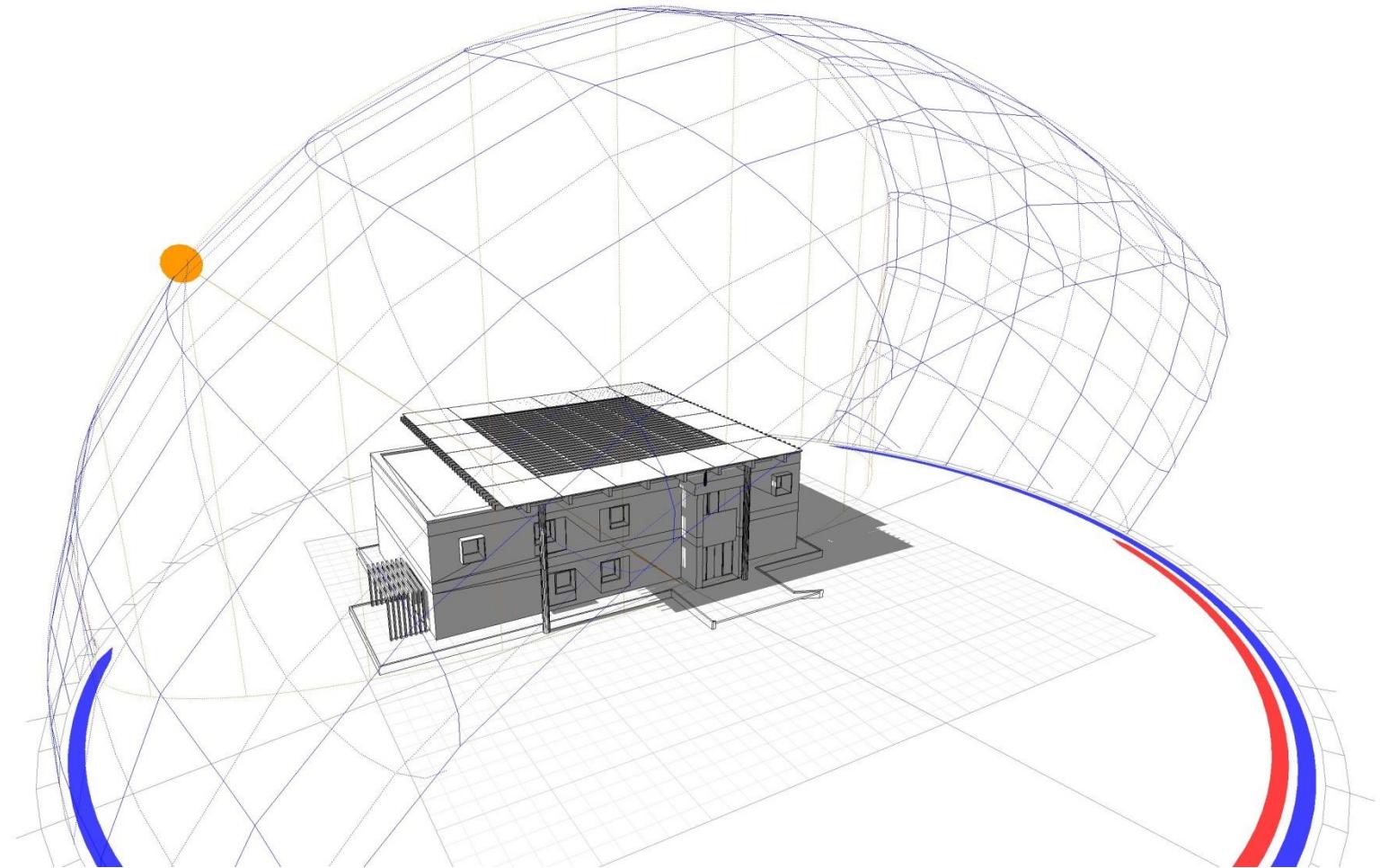
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# Building design

SHADING - DAILY

Summer Solstice:

June, 21th — 16:00



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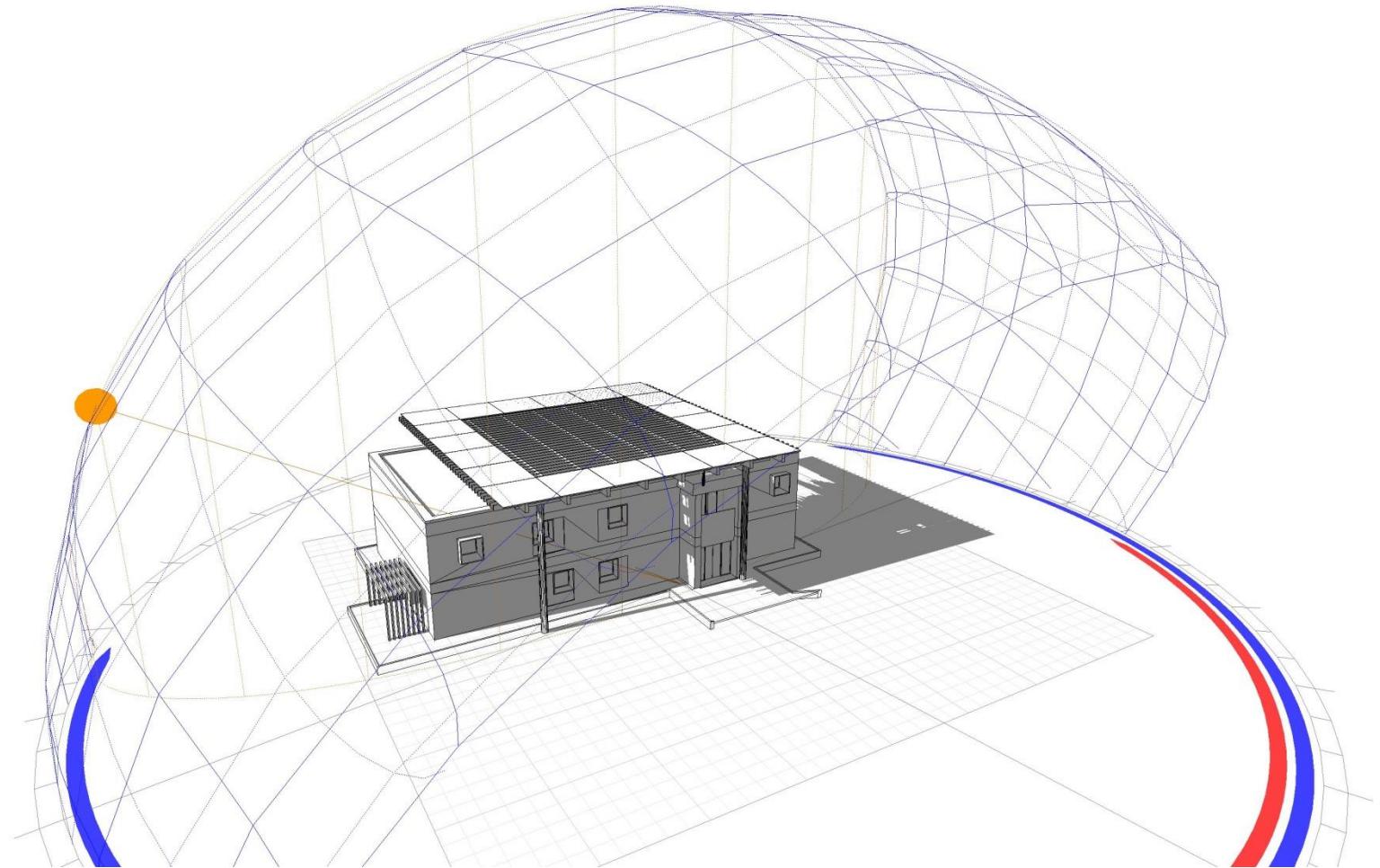
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# Building design

SHADING - DAILY

Summer Solstice:

June, 21th — 17:00



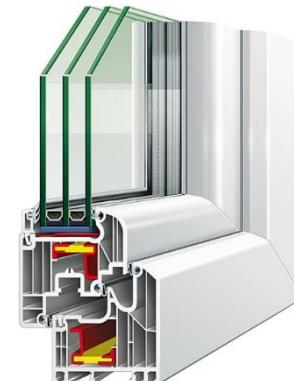
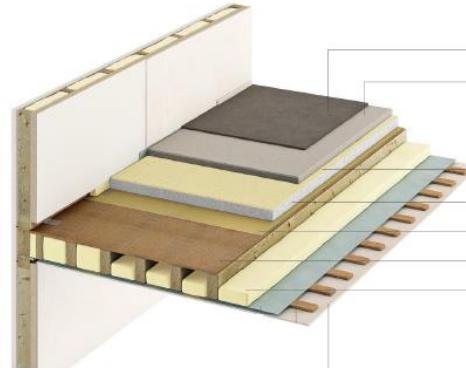
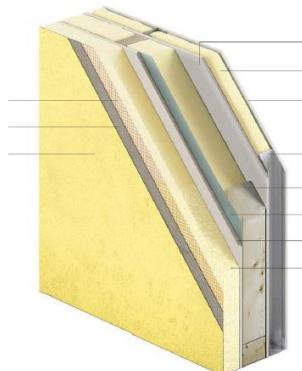
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## Parametri progettuali involucro

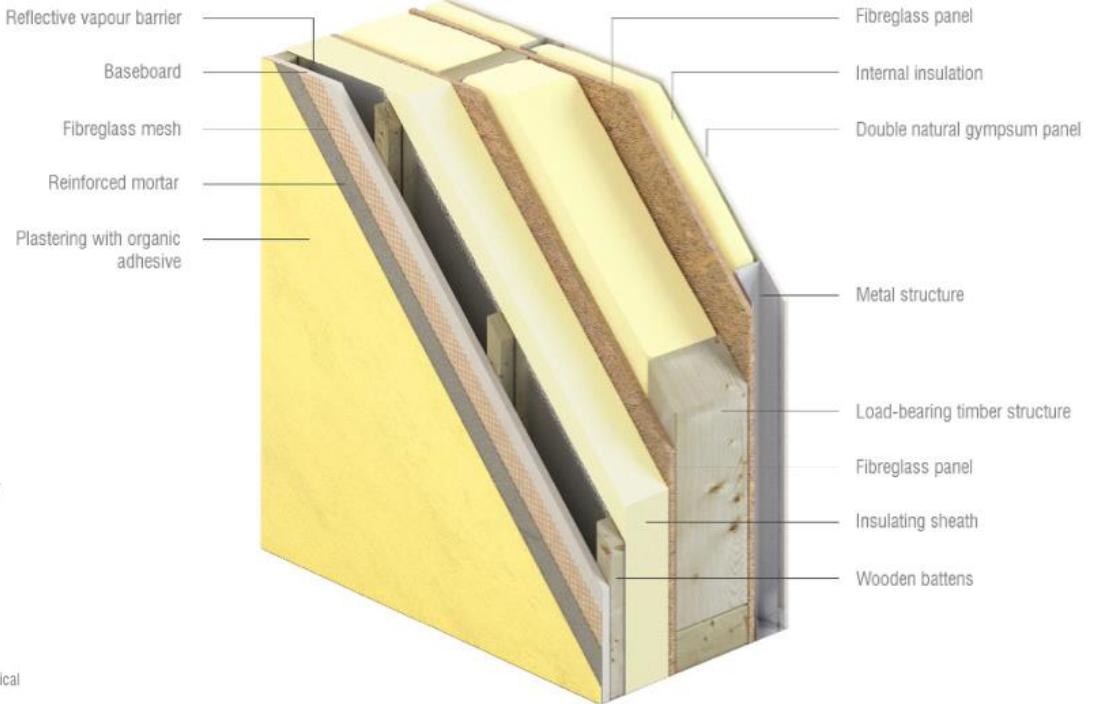
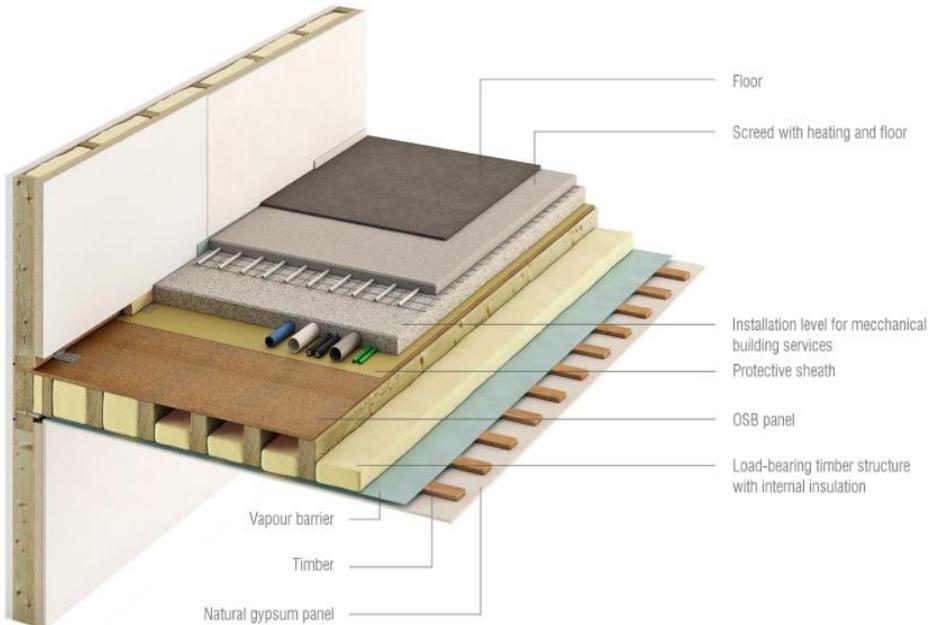
Comfort & Gains			Wall layers & Windows		
	unit	value		unit	value
Set point temperature	°C	24	$U_{wall}$	W/m <sup>2</sup> /K	0.063
Set point relative humidity	%	50	Wall thickness	m	0.603
Mean ventilation ratio	Vol/hr	0.60	Wall solar absorptance	%/100	0.3
HX efficiency	%	80	$U_{roof}$	W/m <sup>2</sup> /K	0.061
Infiltration	Vol/hr	0.06	Roof thickness	m	0.566
Lighting (peak)	W/m <sup>2</sup>	5	Roof solar absorptance	%/100	0.2
Internal gains (peak)	kW	6	$U_{-value,w}$	W/m <sup>2</sup> /K	0.7
Occupancy	Nr.	20	$G_{-value,w}$	%/100	0.294



# Building design

## Pareti prefabbricate in legno

- 61 cm thick external wall,
- U-value = 0.070 W/m<sup>2</sup>K,
- Acoustic Insulation > 65 dB,
- Fire resistance: REI 90.



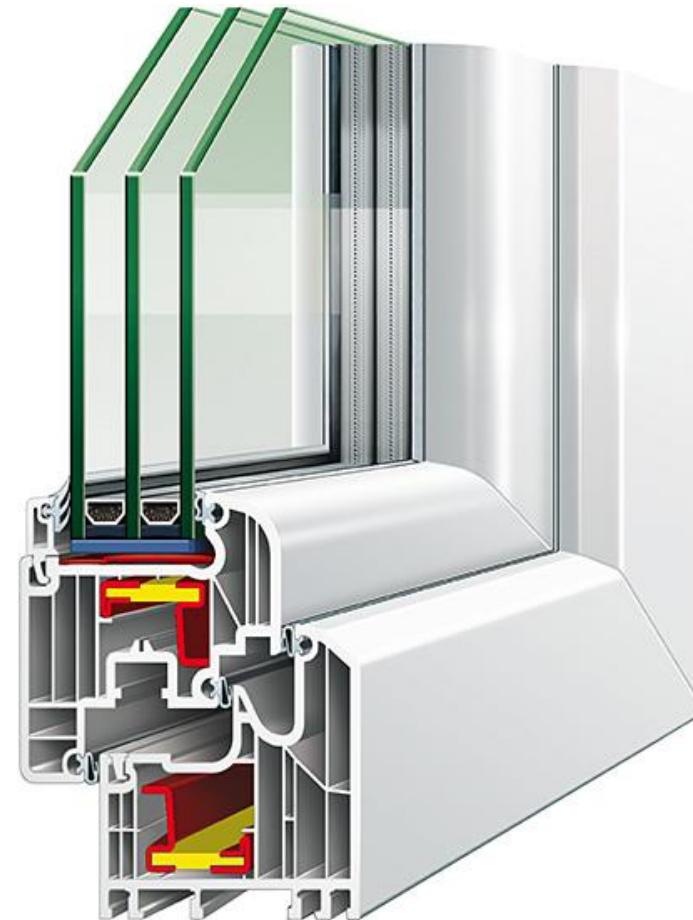
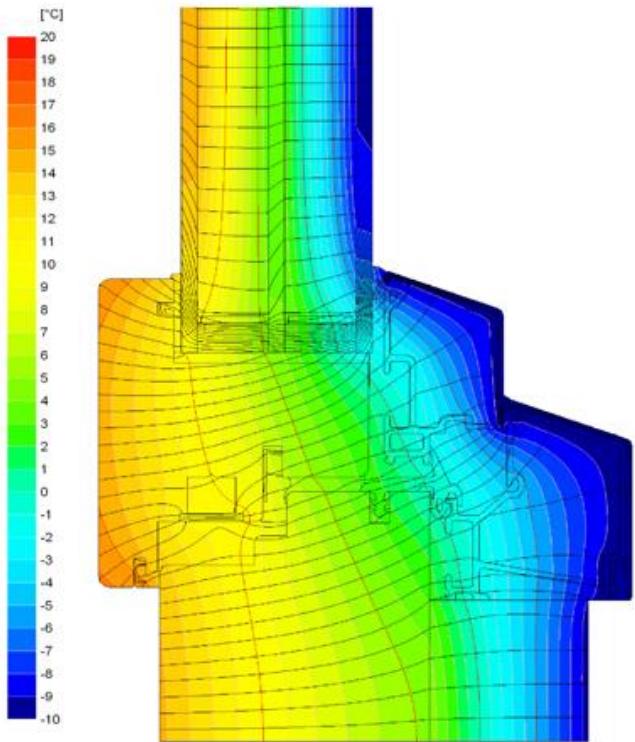
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# Building design

## Windows for Hot Climates

- 6/12/4/12/3+3 glass,
- $U-g = 0.5 \text{ W/m}^2\text{K}$ ,
- Total heat transmission = 28%.

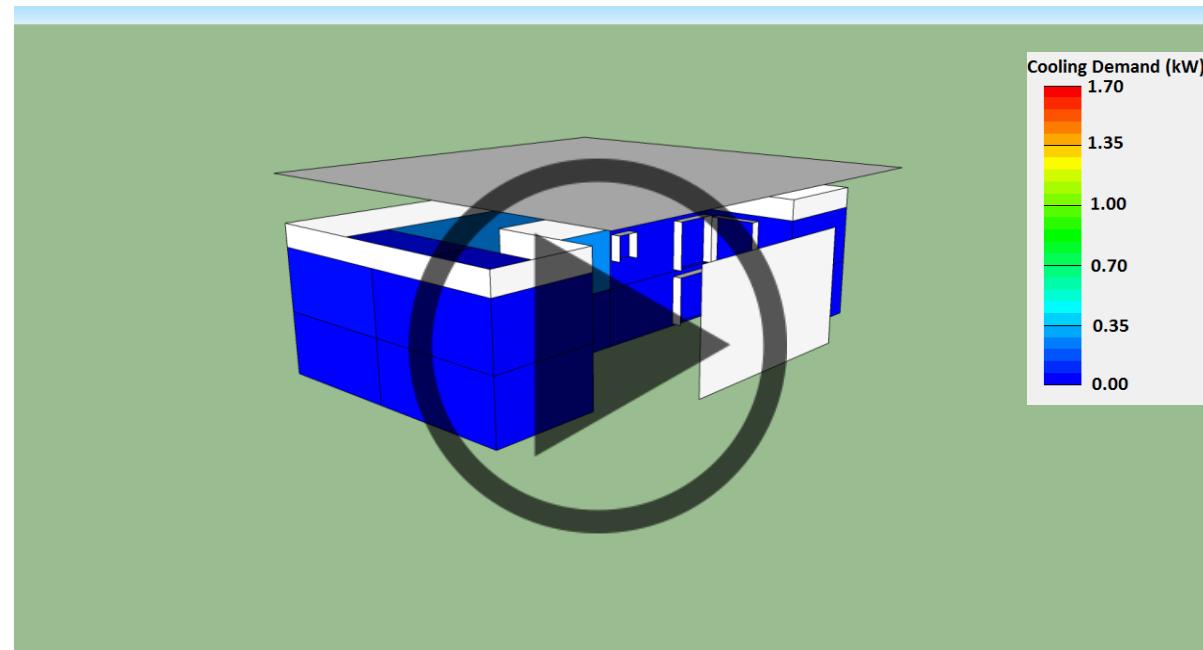


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# Building design

**Simulazione in regime transitorio del fabbisogno di energia frigorifera**

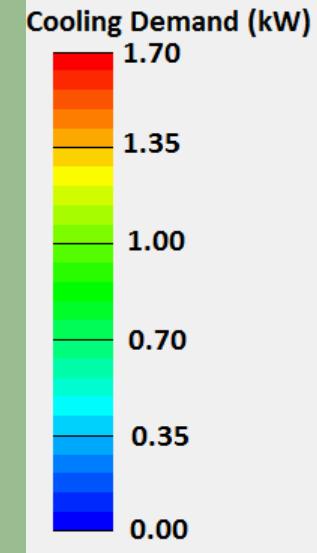
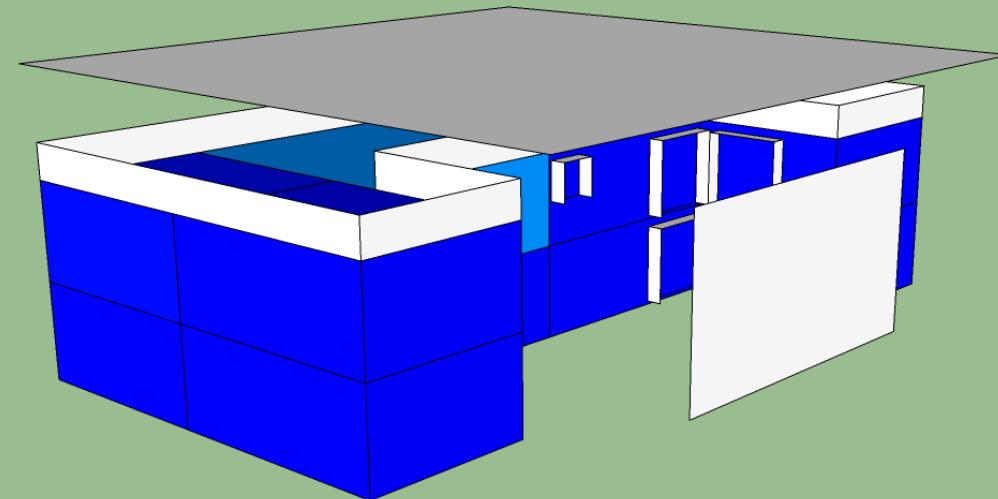


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July 10  
time 2:00

## TrnSys Simulation Results

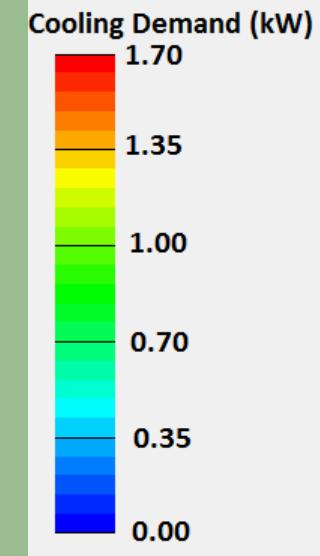
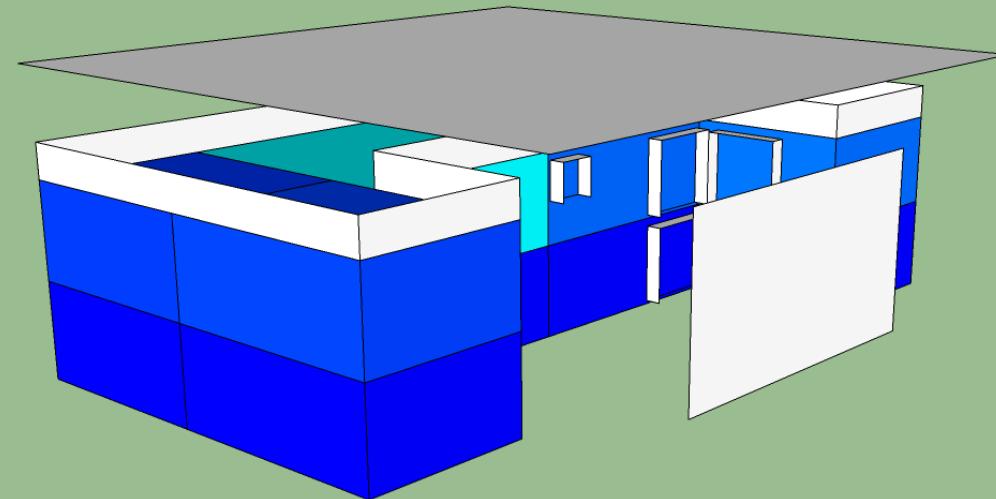


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July 10  
time 2:40

## TrnSys Simulation Results

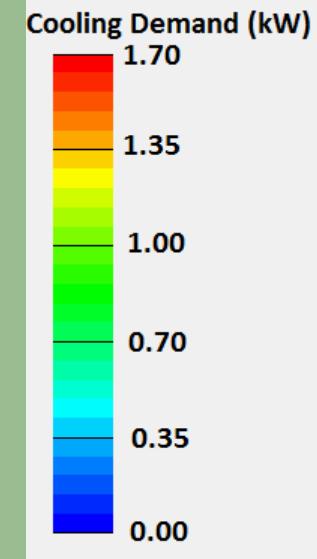
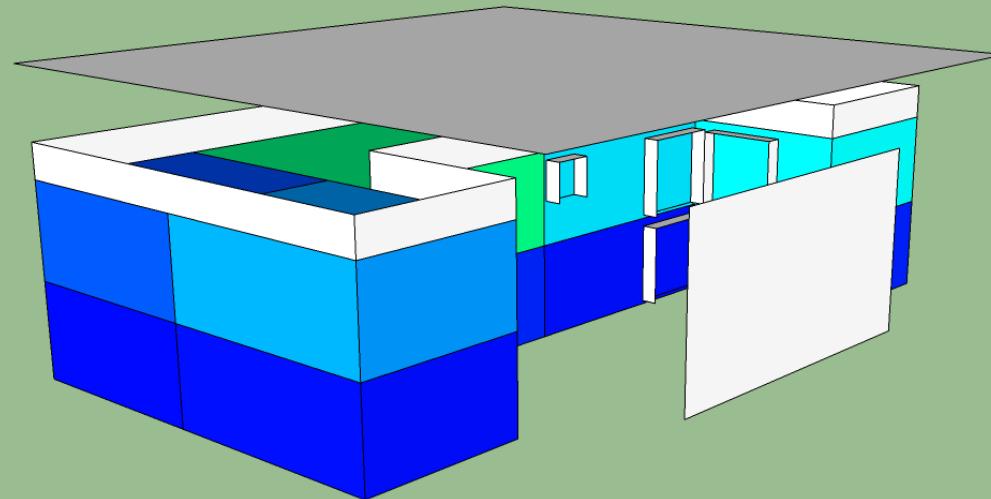


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July 10  
time 3:20

## TrnSys Simulation Results

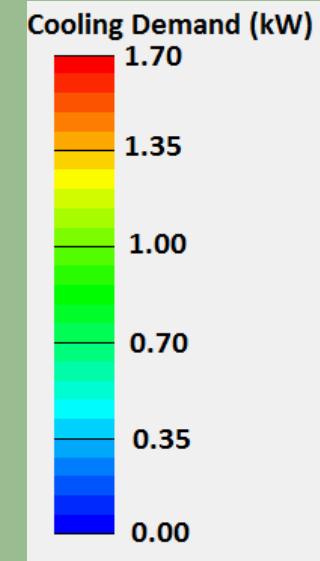
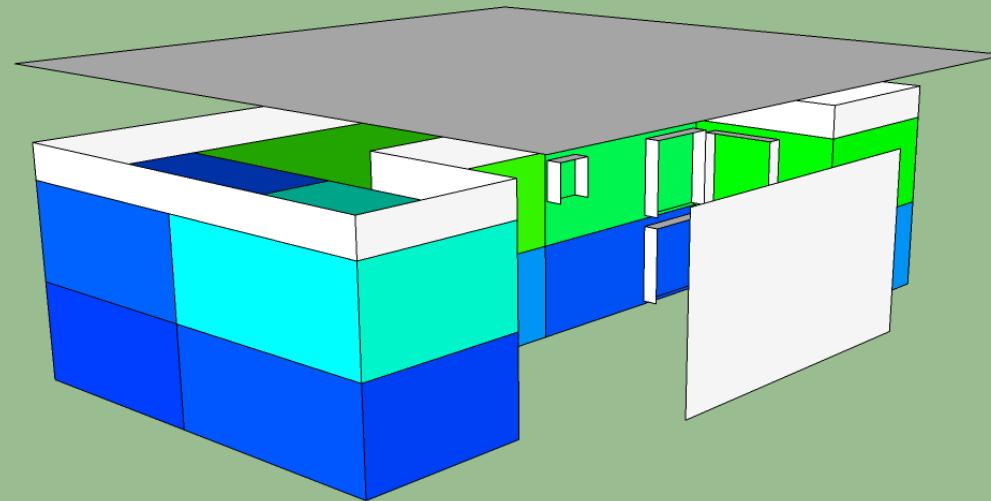


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July 10  
time 4:00

## TrnSys Simulation Results

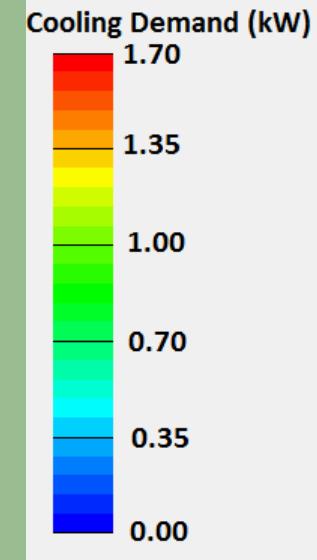
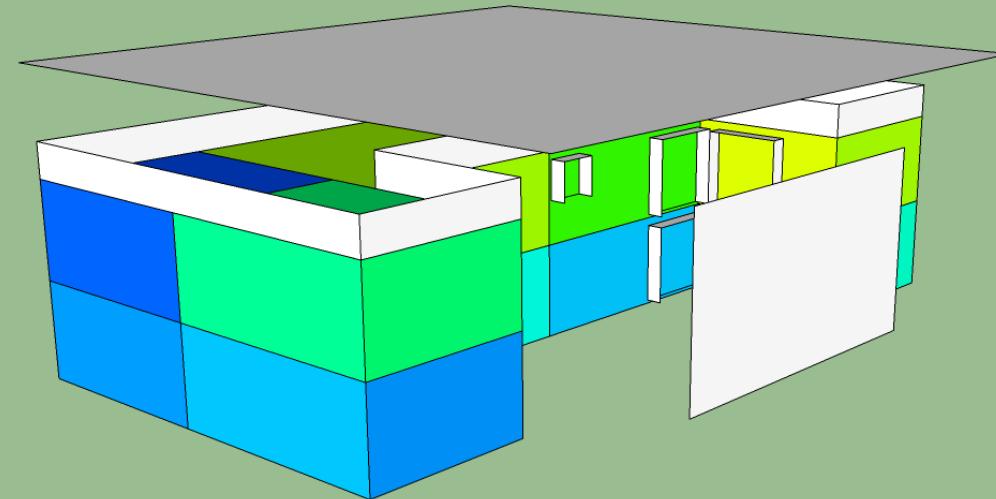


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July 10  
time 4:40

## TrnSys Simulation Results

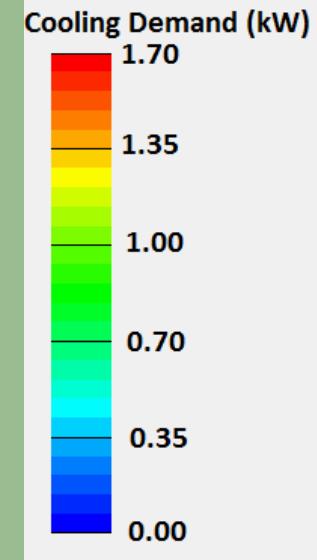
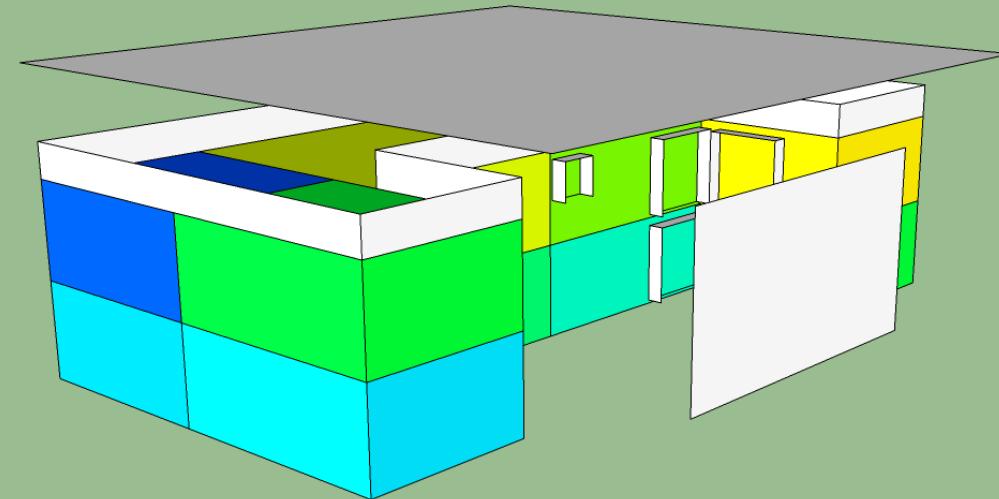


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July 10  
time 5:20

## TrnSys Simulation Results

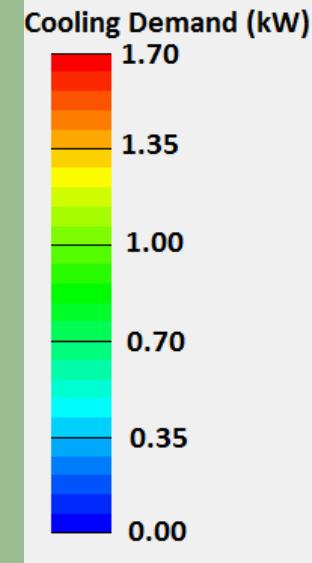
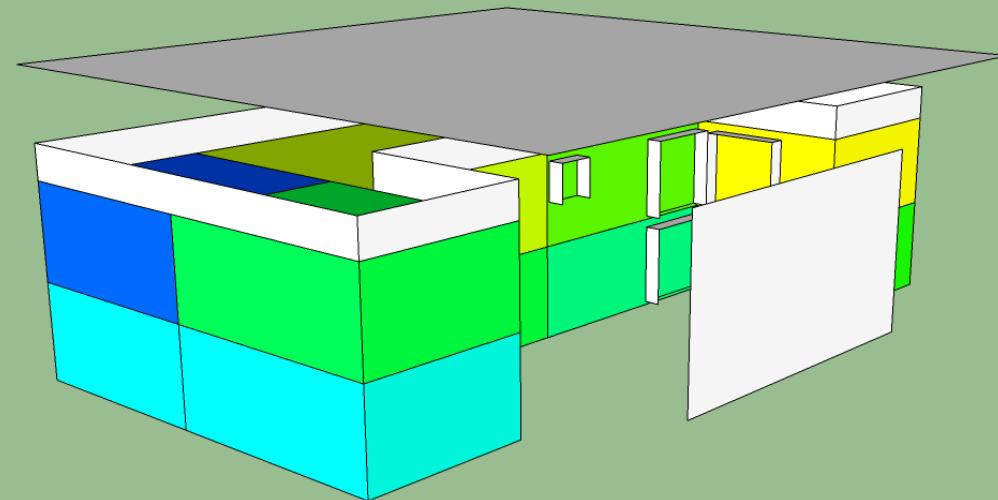


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July 10  
time 6:00

## TrnSys Simulation Results

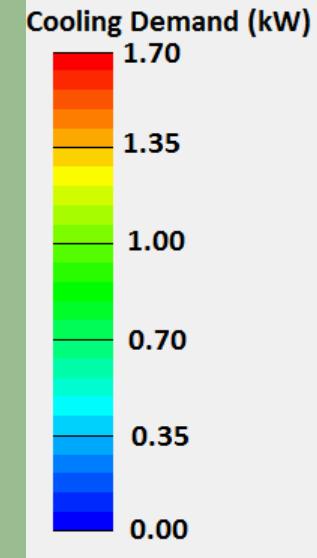
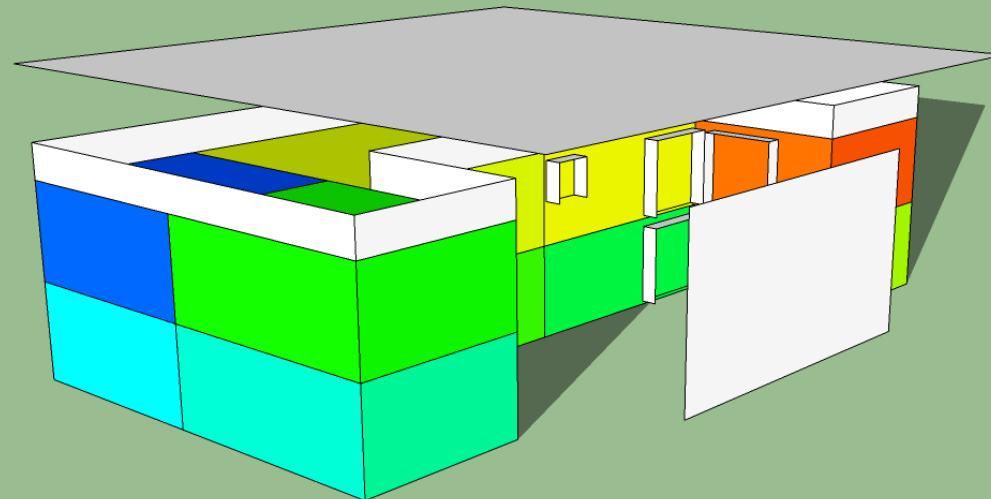


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July 10  
time 6:40

## TrnSys Simulation Results

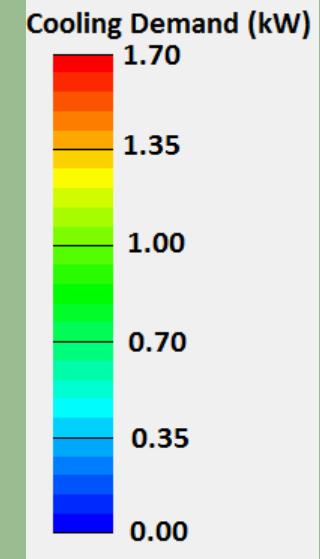
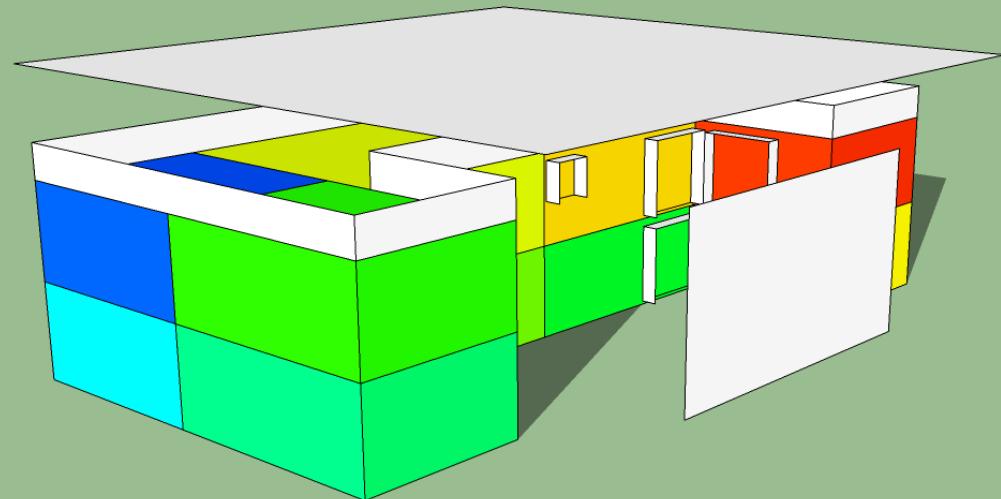


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July 10  
time 7:20

## TrnSys Simulation Results

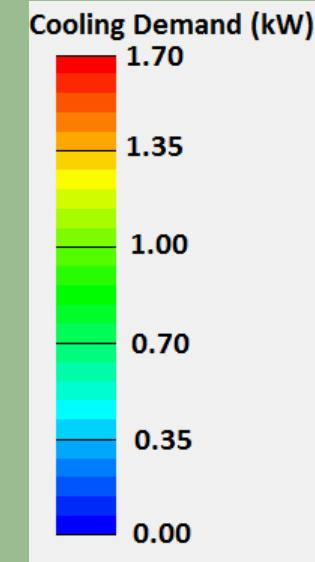
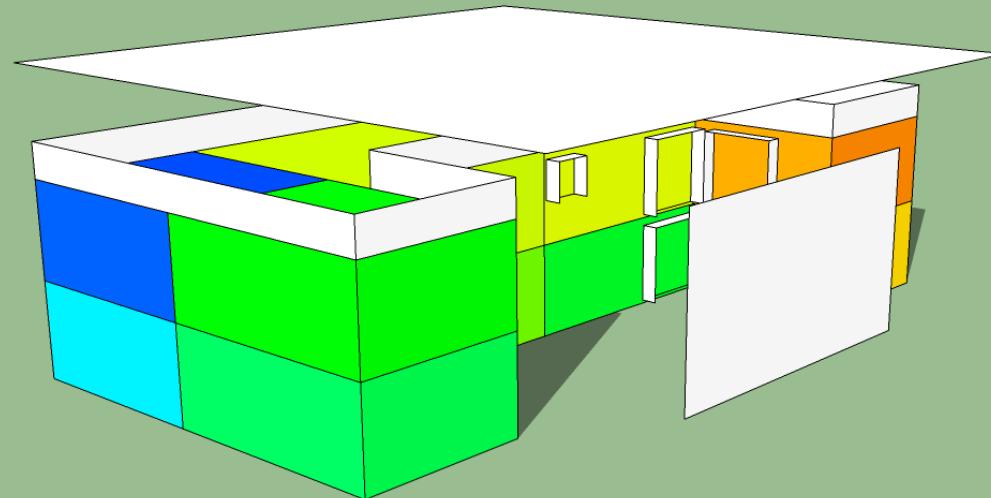


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July 10  
time 8:00

## TrnSys Simulation Results

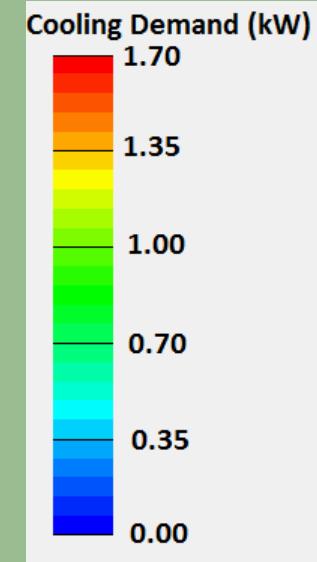
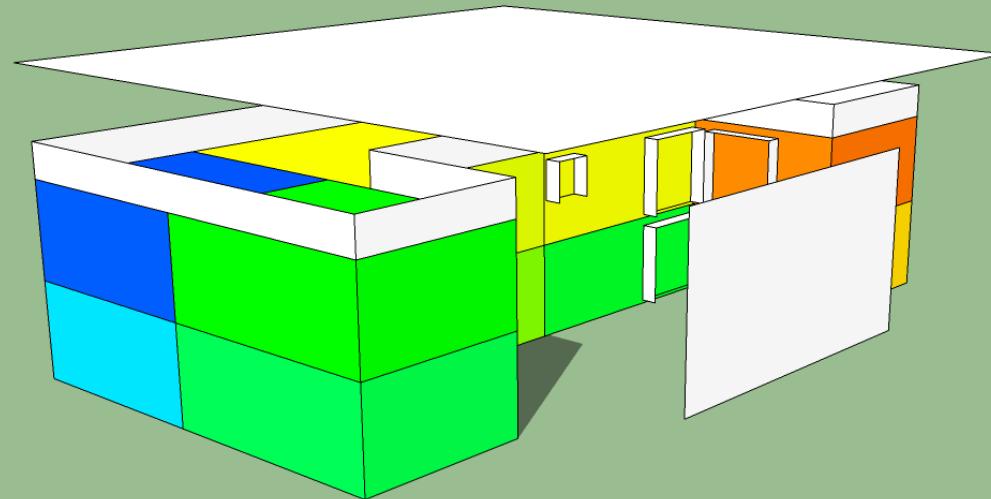


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of Engineering  
and Applied Sciences

July 10  
time 8:40

## TrnSys Simulation Results

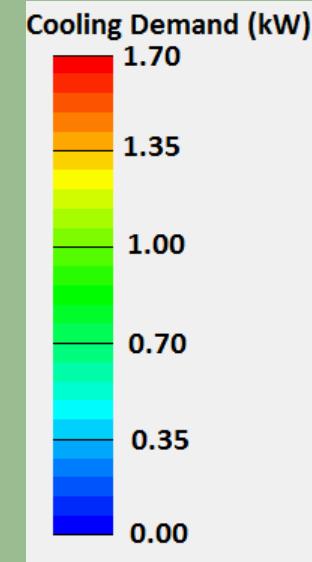
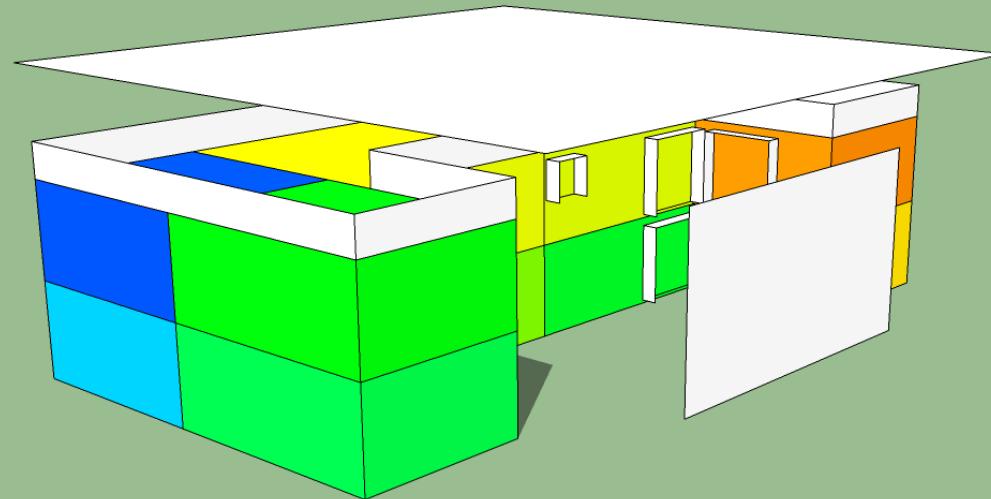


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July 10  
time 9:20

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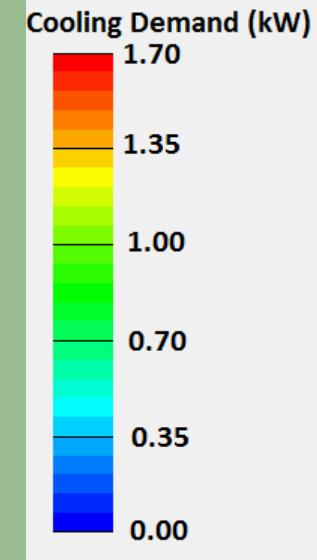
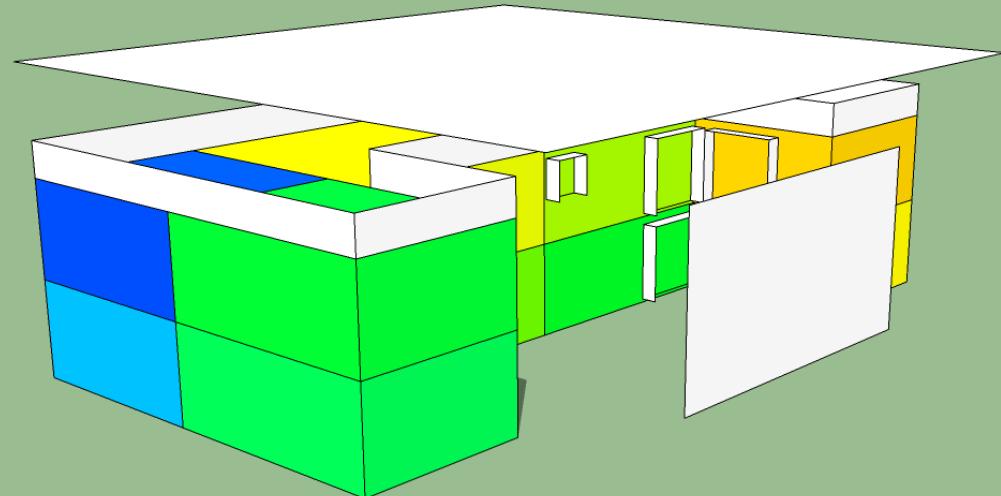


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July 10  
time 10:00

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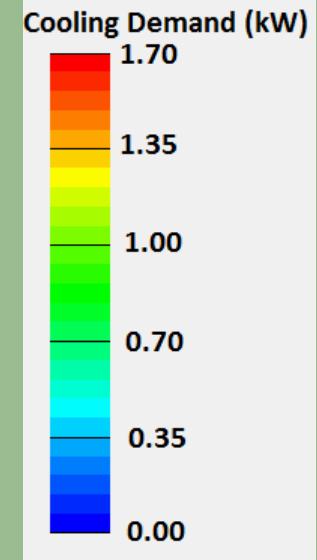
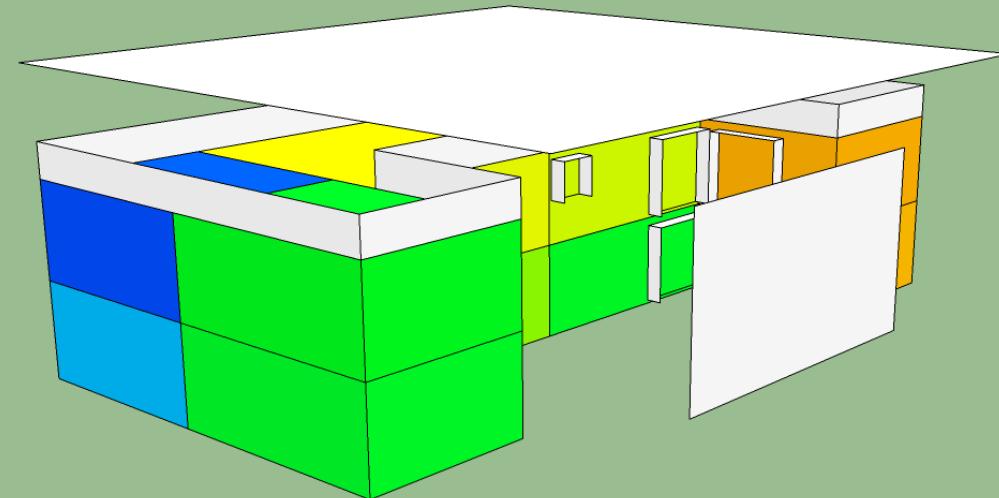


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and Applied Sciences

July 10  
time 10:40

## TrnSys Simulation Results

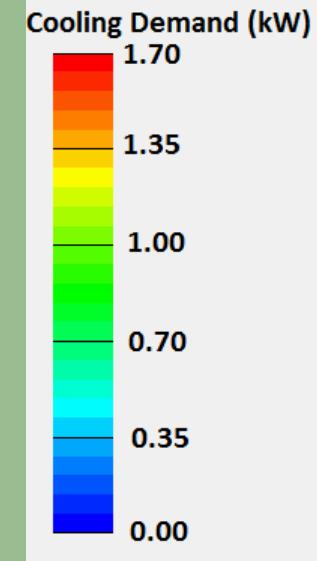
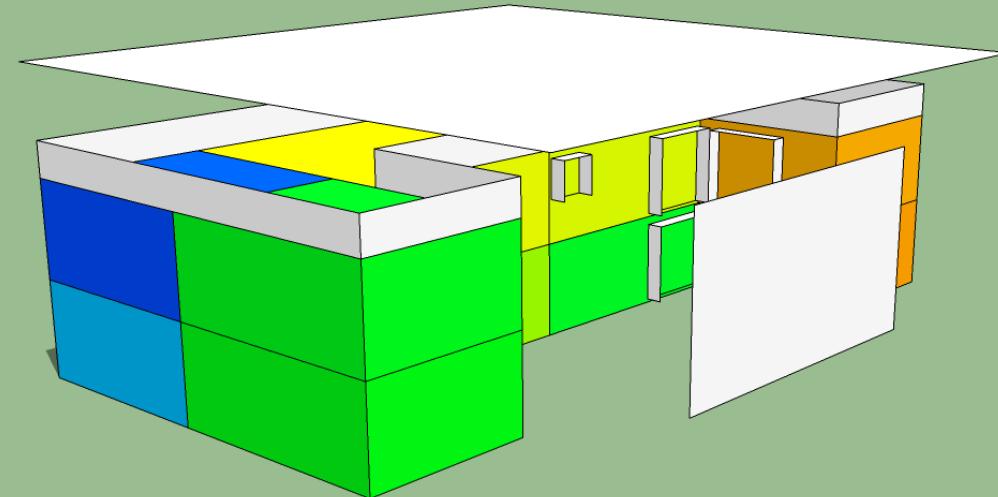


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and Applied Sciences

July 10  
time 11:20

## TrnSys Simulation Results

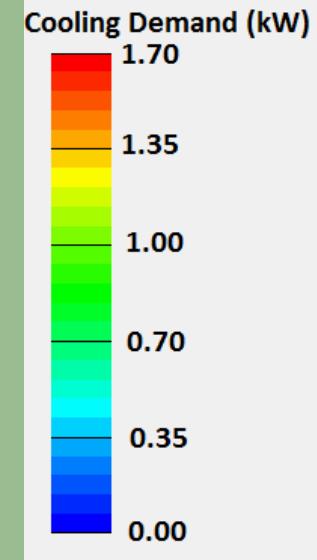
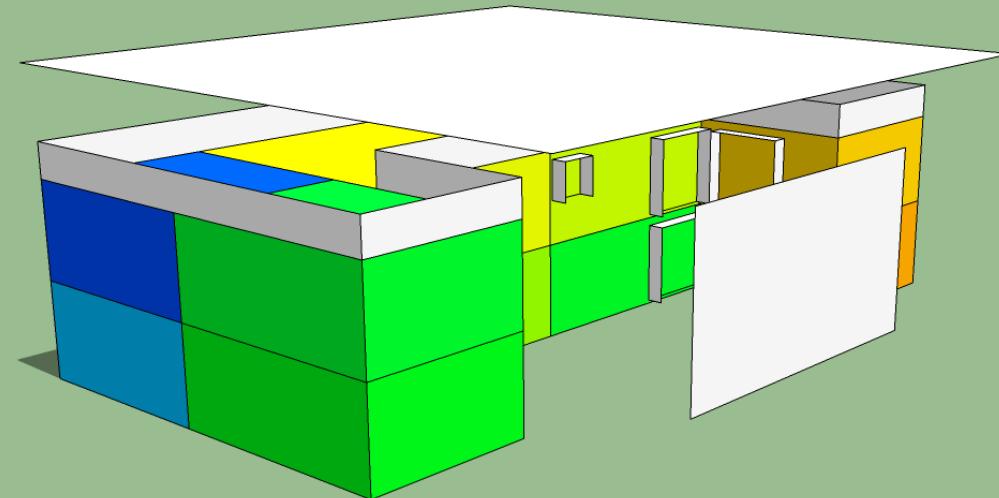


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July 10  
time 12:00

## TrnSys Simulation Results

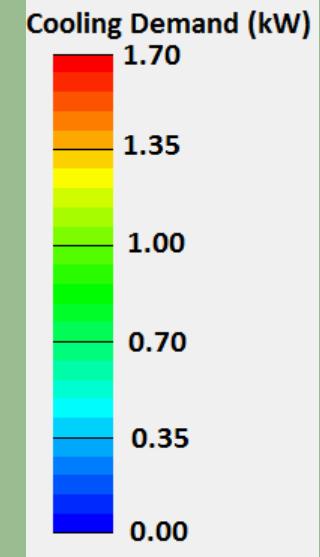
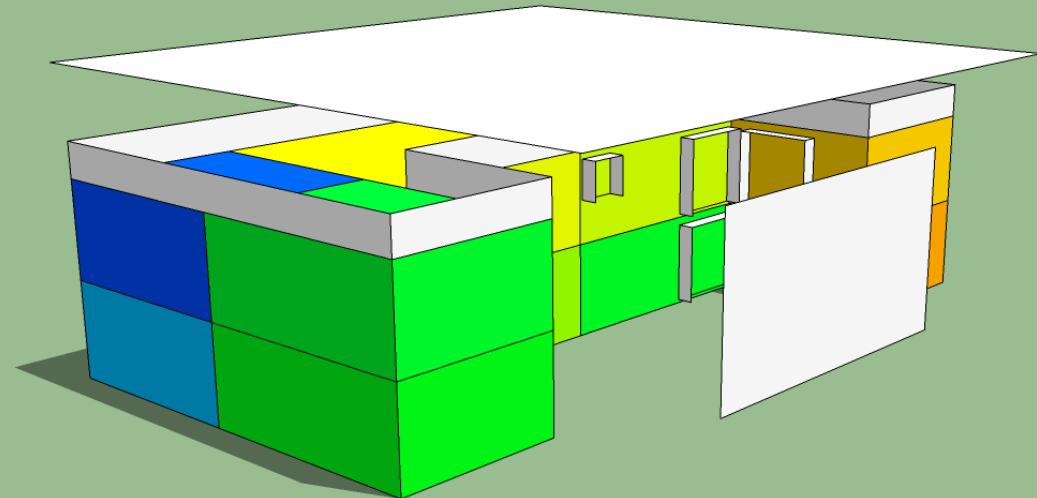


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and Applied Sciences

July 10  
time 12:40

## TrnSys Simulation Results

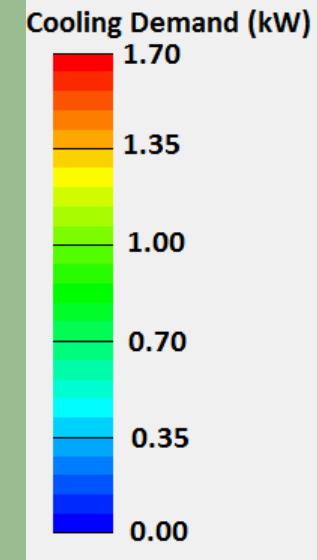
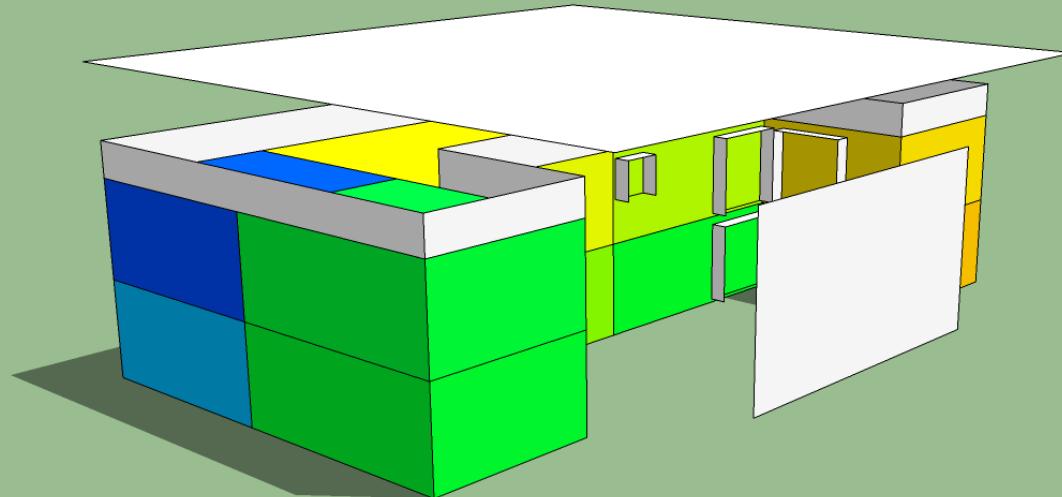


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July 10  
time 13:20

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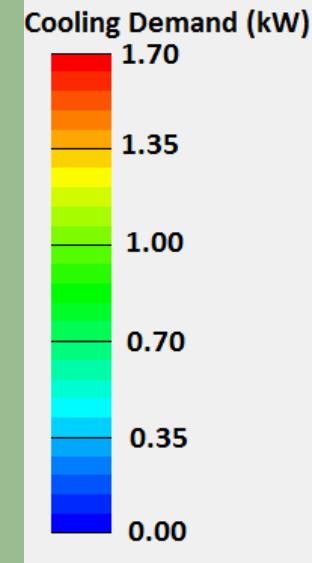
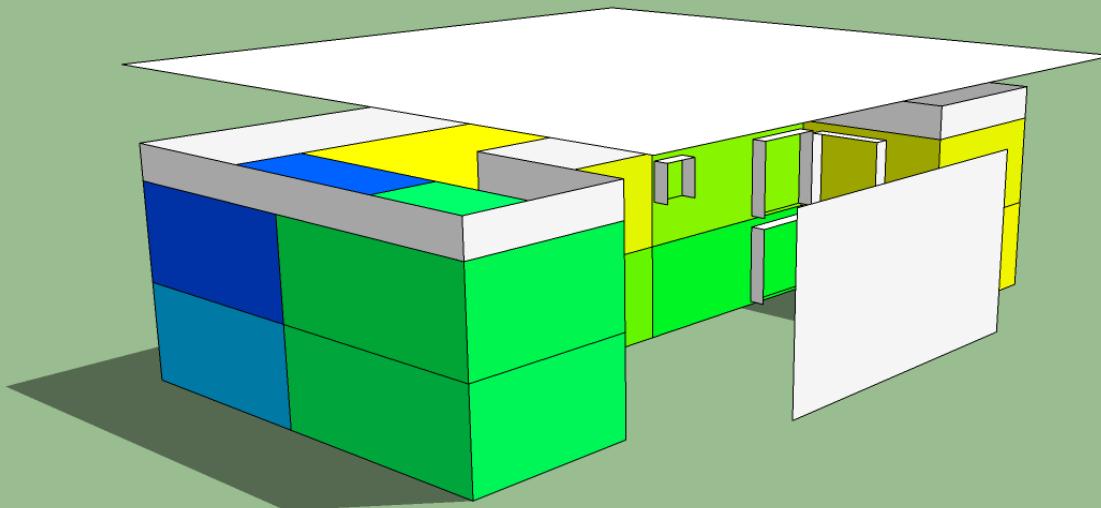


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July 10  
time 14:00

## TrnSys Simulation Results

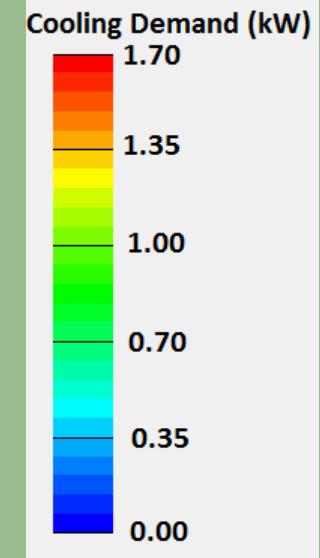
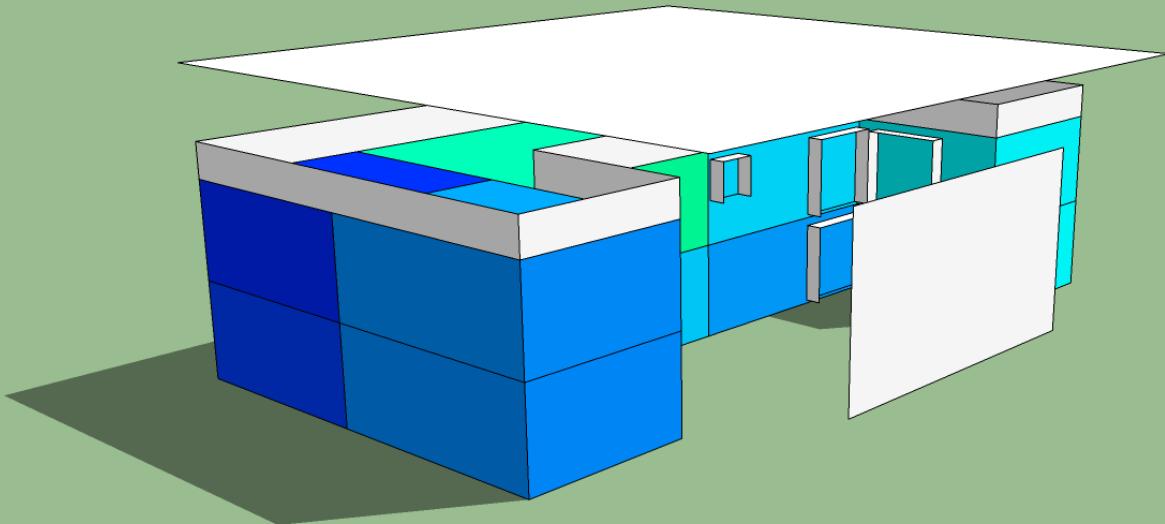


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July 10  
time 14:40

## TrnSys Simulation Results

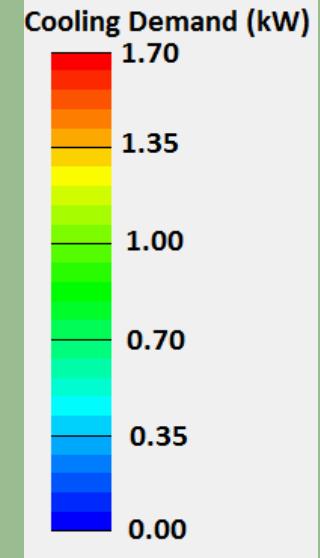
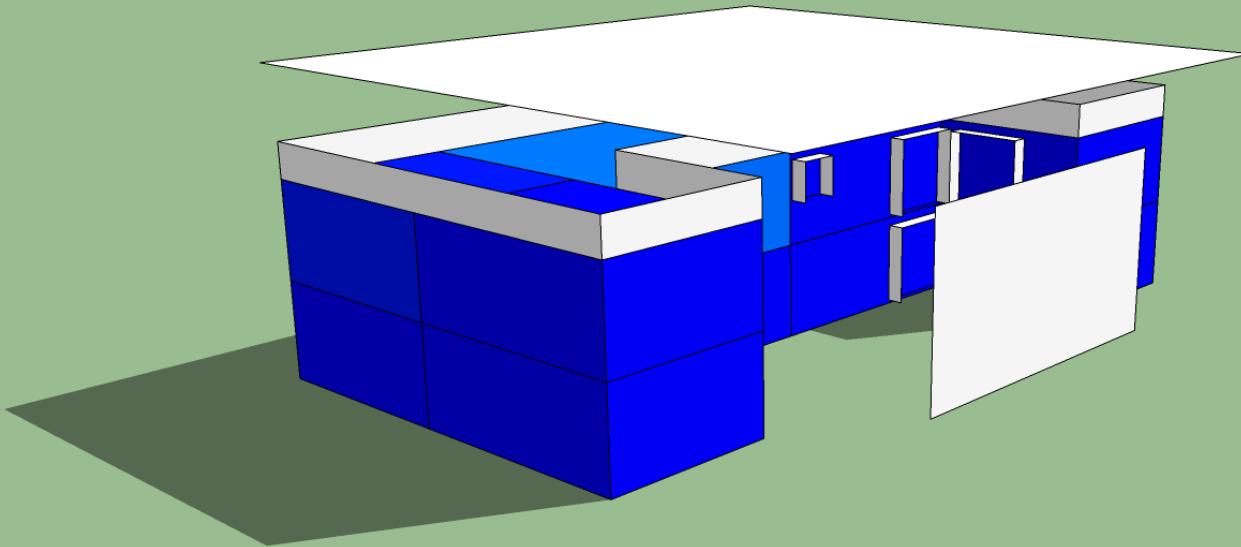


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July 10  
time 15:20

## TrnSys Simulation Results

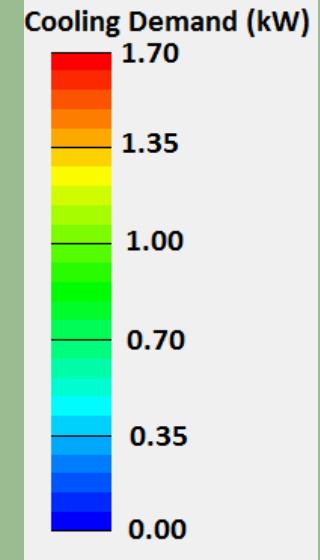
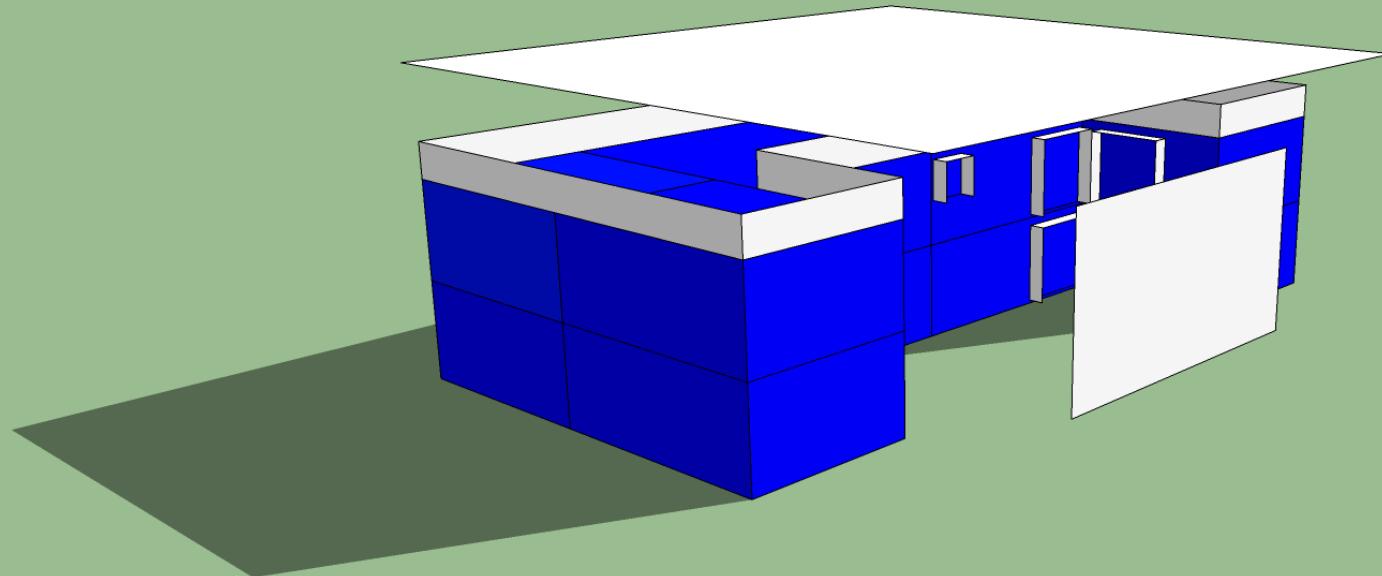


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July 10  
time 16:00

## TrnSys Simulation Results

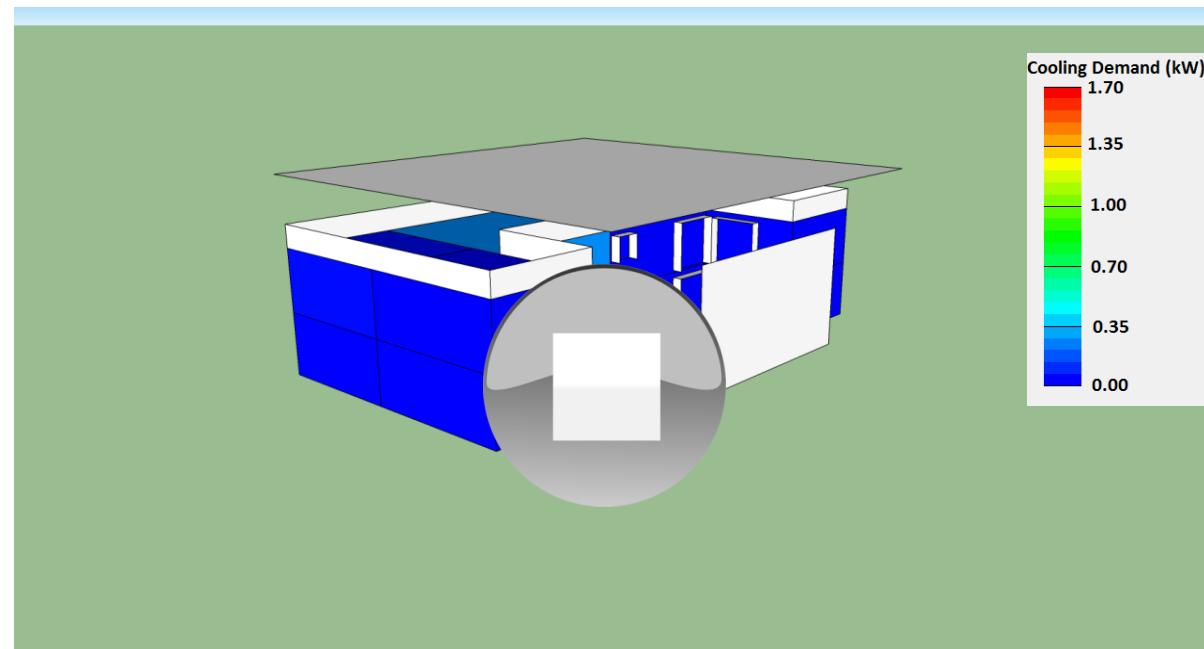


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# Building design

**Simulazione in regime transitorio del fabbisogno di energia frigorifera**



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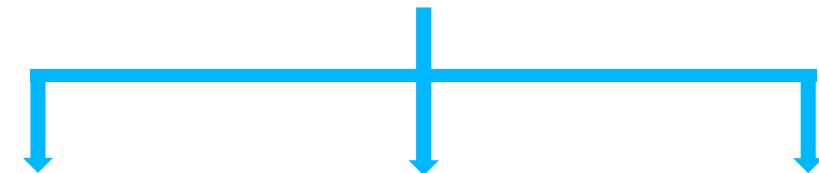
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# Building design

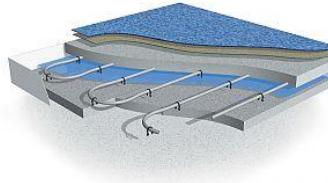
Comfort & Gains		
	unit	value
<b>Set point temperature</b>	°C	24
<b>Set point relative humidity</b>	%	50
<b>Mean ventilation ratio</b>	Vol/hr	0.60
<b>HX efficiency</b>	%	80
<b>Infiltration</b>	Vol/hr	0.06
<b>Lighting (peak)</b>	W/m <sup>2</sup>	5
<b>Internal gains (peak)</b>	kW	6
<b>Occupancy</b>	Nr.	20



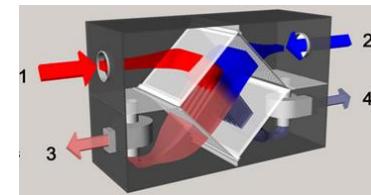
Triple distribution system



Floor cooling



AHU (w/ heat recovery)



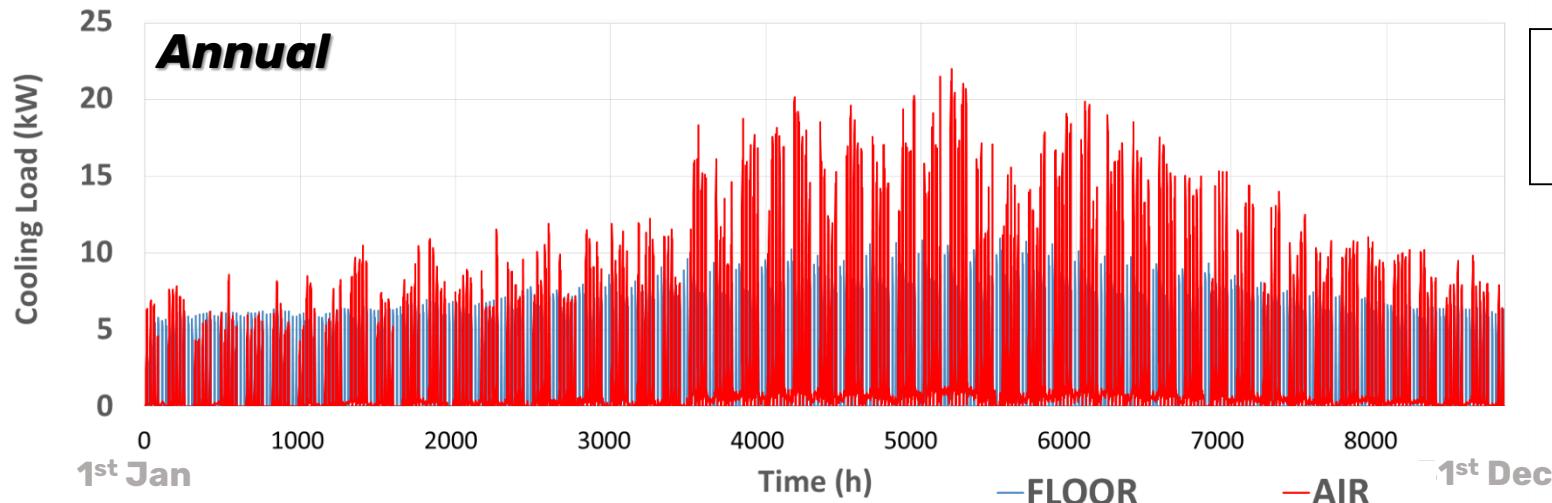
Fan coils



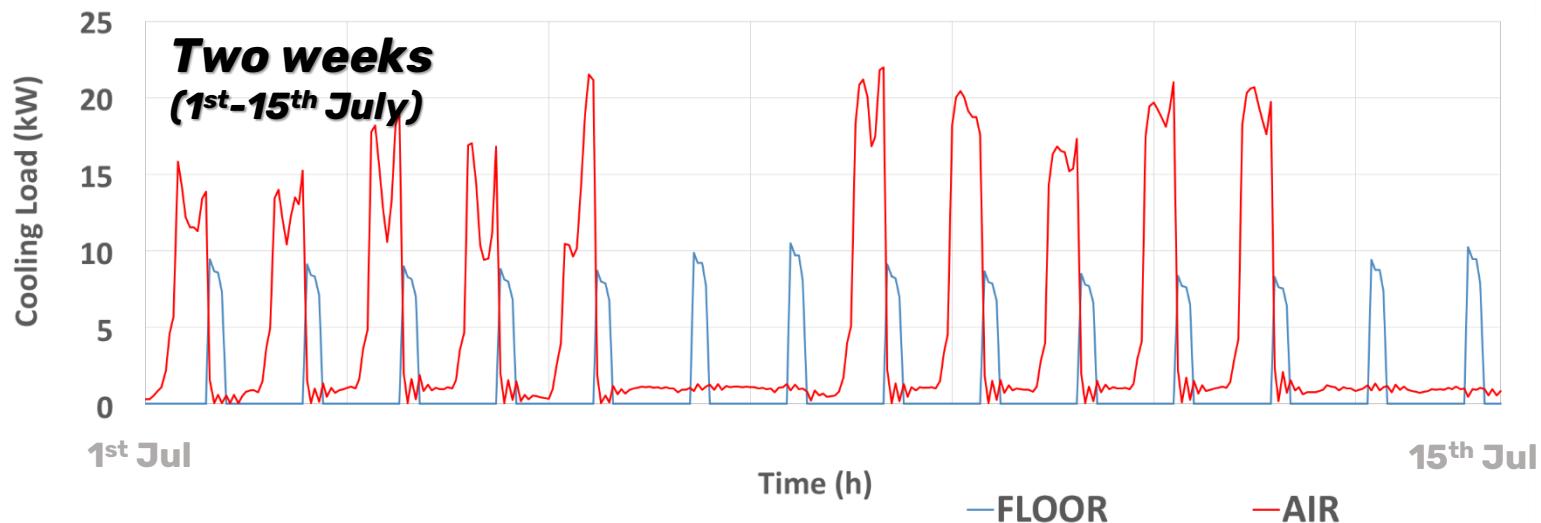
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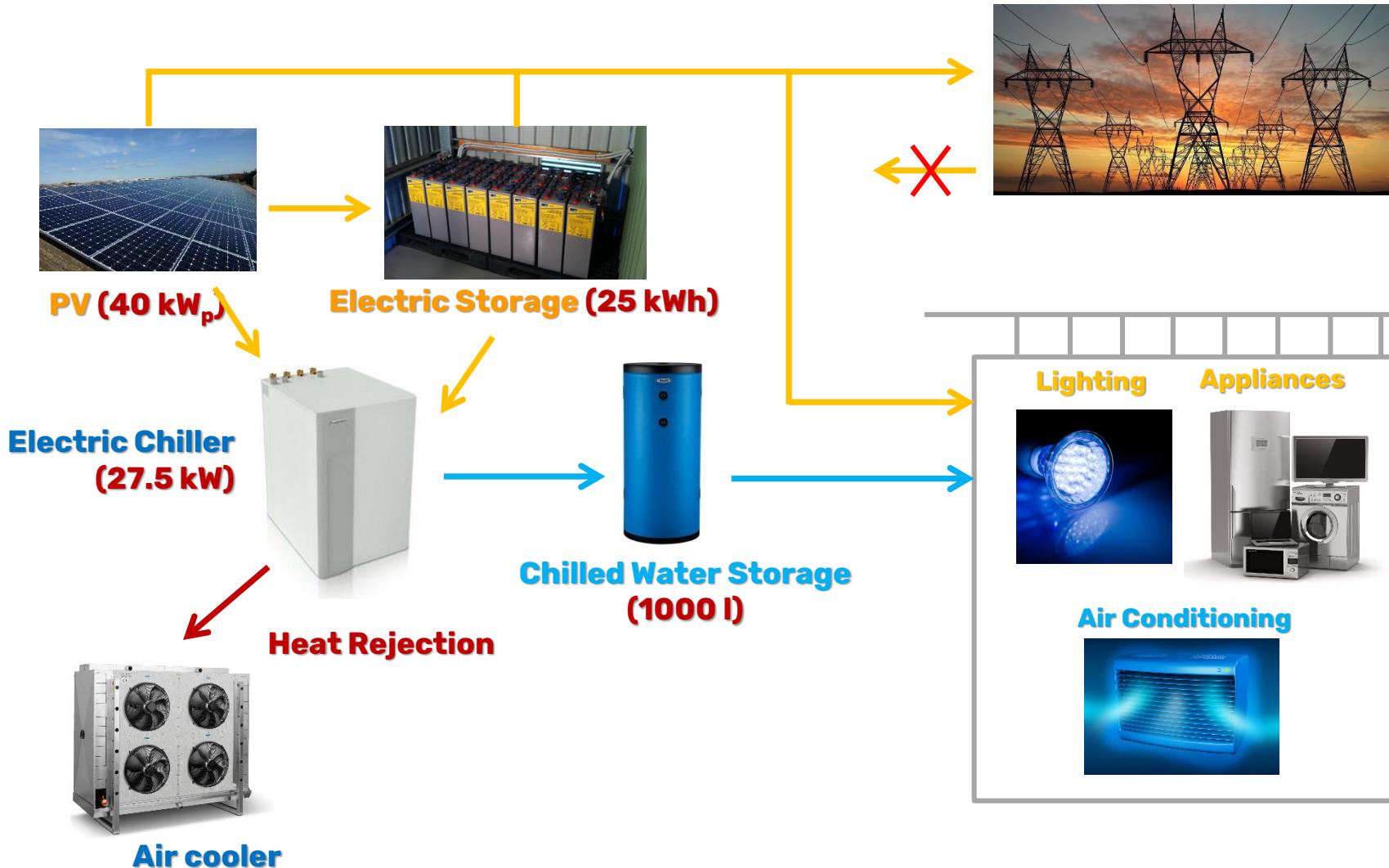
# Building design



**CONTROL STRATEGY:**  
Air: 5<sup>h</sup>-15<sup>h</sup> (5/7, workdays)  
Floor: 15<sup>h</sup>-19<sup>h</sup> (7/7)



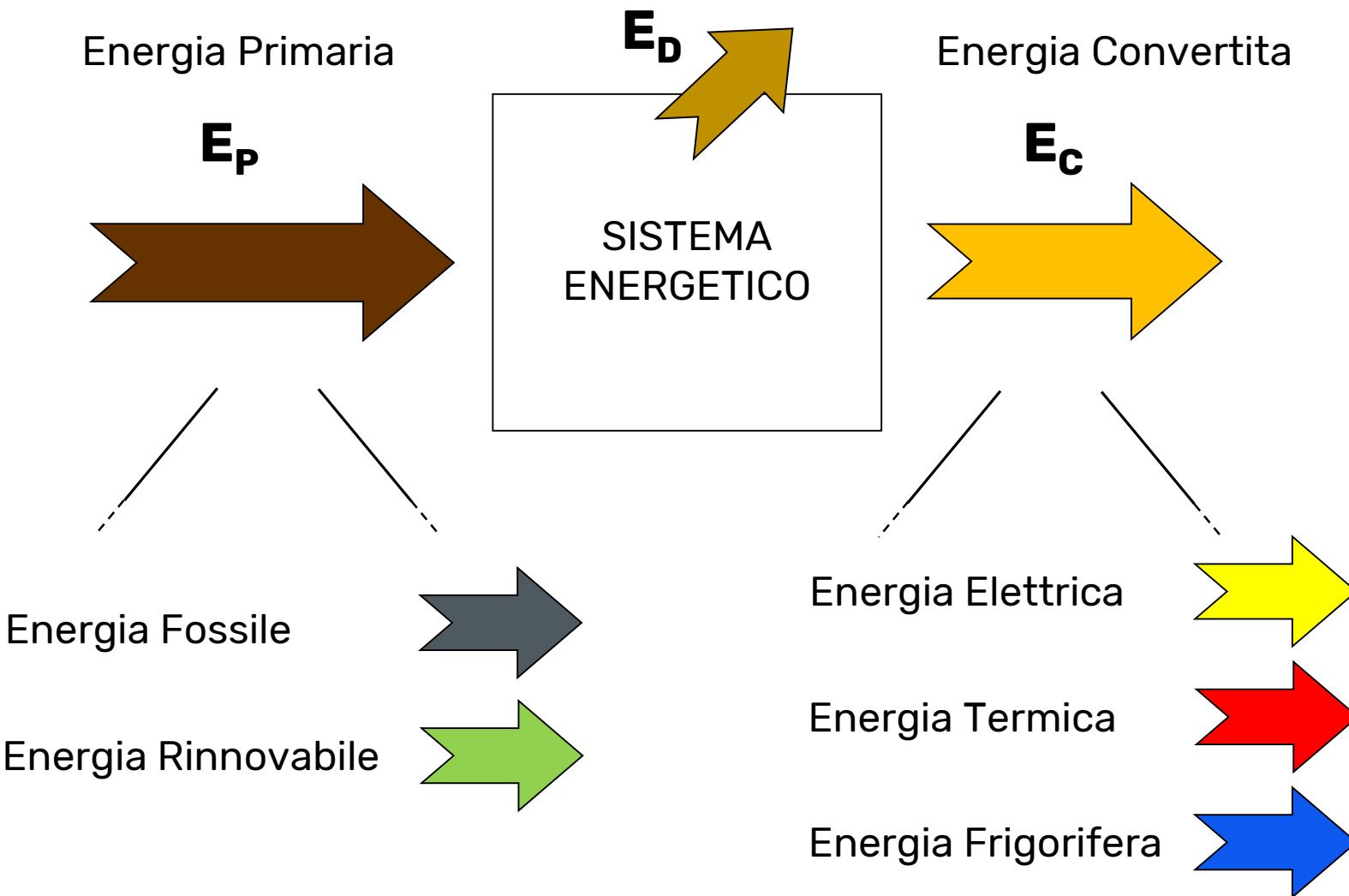
# Building design



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# Principi di conversione dell'energia



**Rendimento di conversione:**

$$\eta_{conv} = \frac{E_C}{E_P}$$

**Energia dissipata:**

$$E_D = E_P - E_C$$



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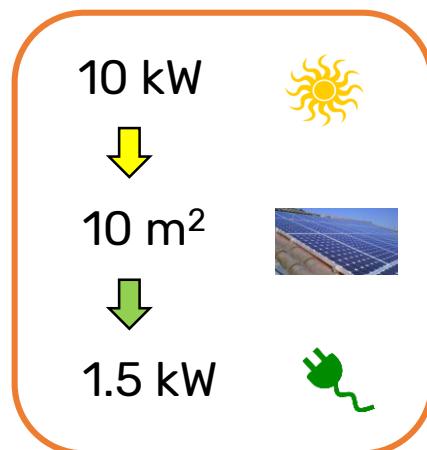
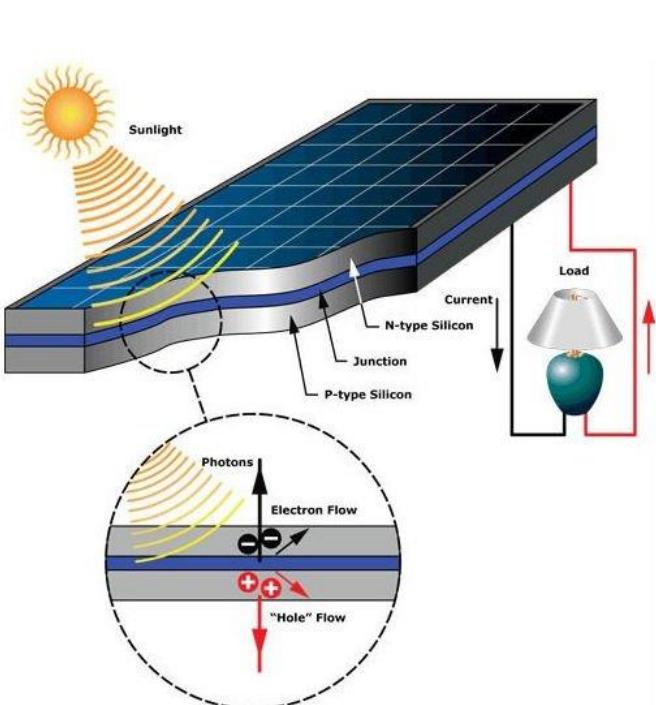
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# Principi di conversione dell'energia

Energia primaria	Energia convertita				
	chimica	radiante	elettrica	meccanica	termica
nucleare					<i>Reattori nucleari</i>
chimica			<i>Fuel cells, batterie</i>		<i>Caldaie, Combustori</i>
radiante	<i>Fotosintesi</i>		<i>Celle fotovoltaiche</i>		<i>Collettori solari</i>
elettrica	<i>Elettrolisi</i>	<i>Lampade</i>		<i>Motori elettrici</i>	<i>Pompe di calore</i>
meccanica			<i>Alternatori</i>	<i>Turbine</i>	
termica				<i>Motori termodinamici</i>	<i>Scambiatori di calore</i>



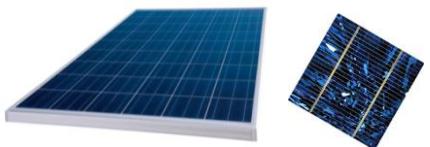
# Solare fotovoltaico



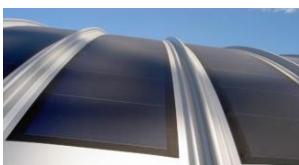
Moduli fotovoltaici (PV)



Silicio monocristallino



Silicio policristallino



Film sottile



# Solare termico



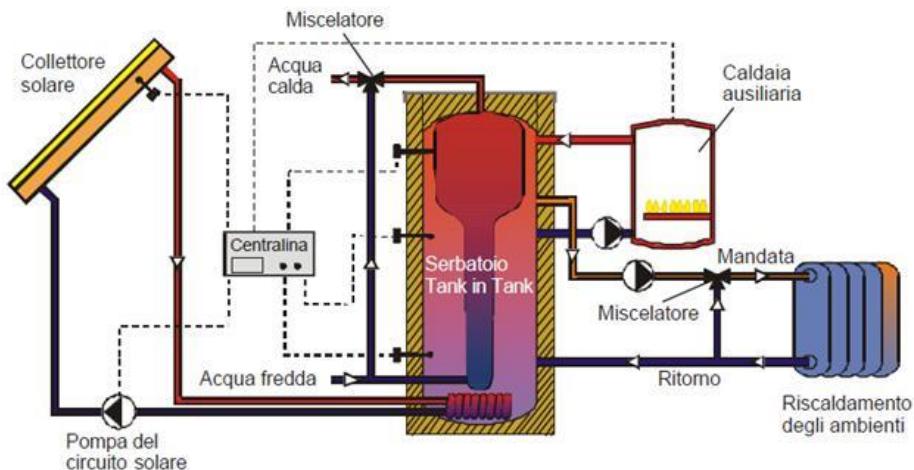
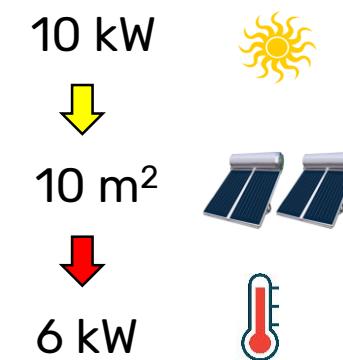
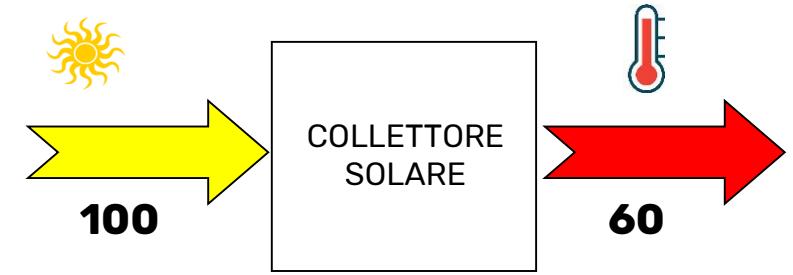
Collettori piani  
vetrati



Collettori non  
vetrati (unglazed)



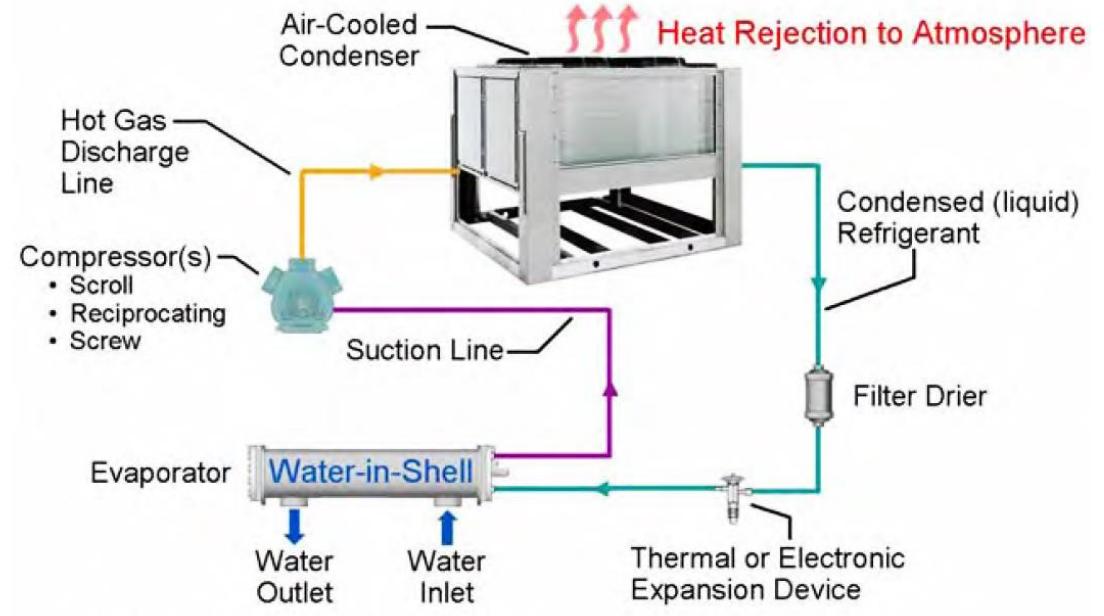
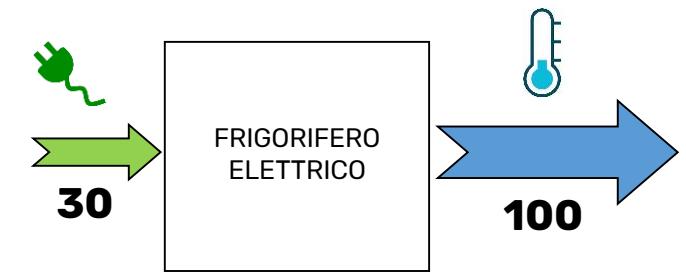
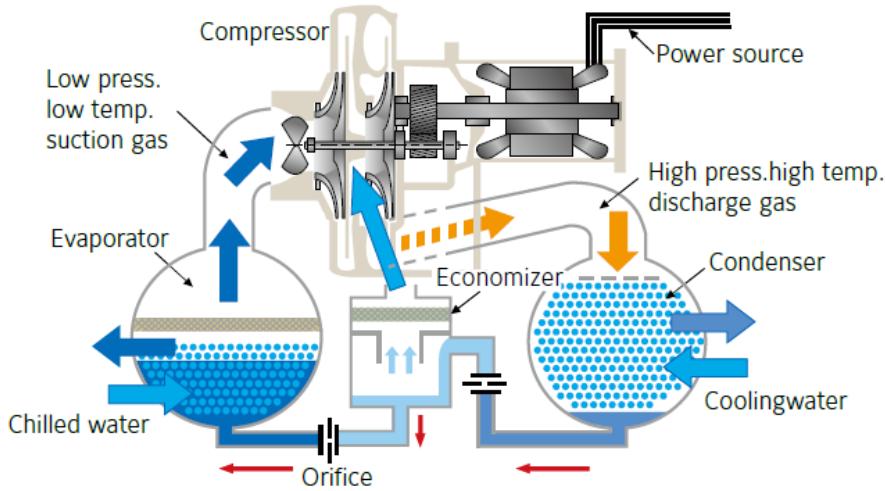
Collettori a tubi  
sottovuoto



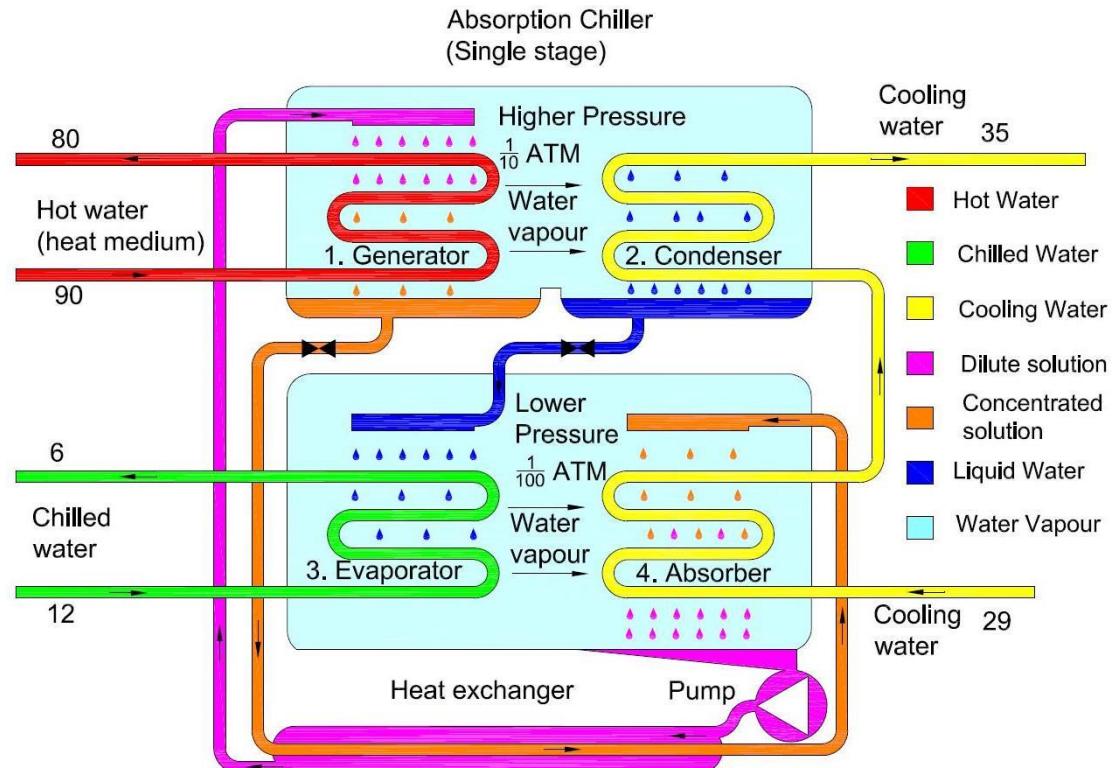
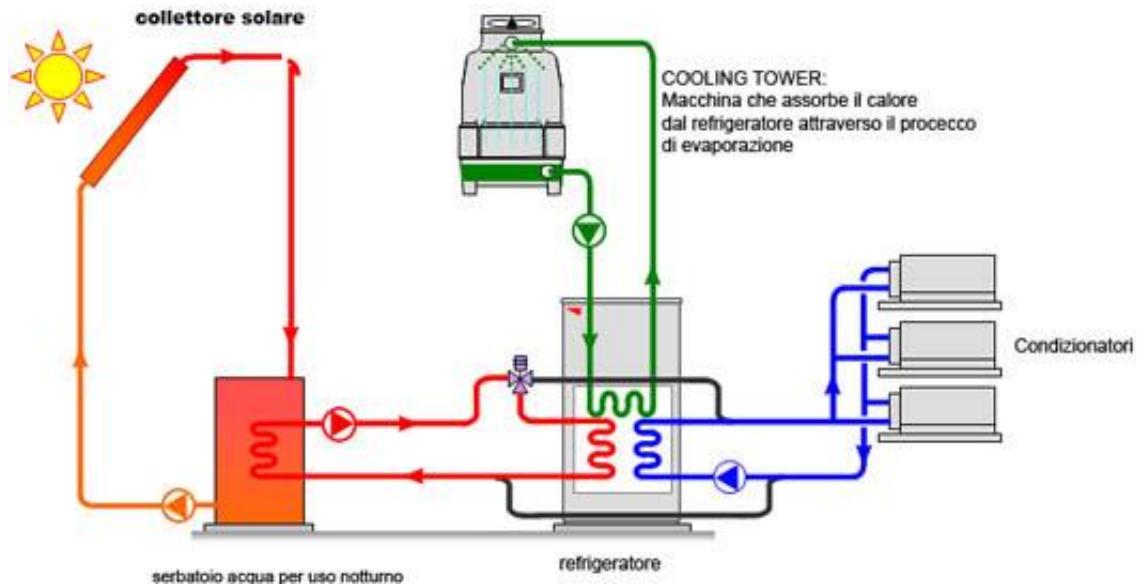
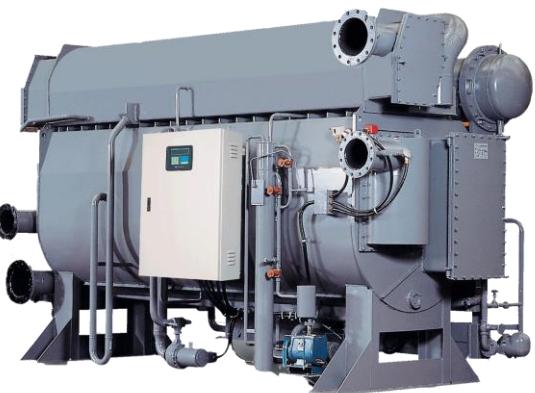
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# Frigorifero elettrico



# Frigorifero ad assorbimento



# Solar Cooling

## Solar Cooling termico

Campo solare



Collettori piani



Collettori sottovuoto

Accumulo

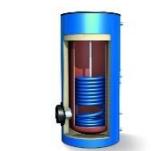


Frigorifero



Frigorifero ad assorbimento

Accumulo



## Solar Cooling elettrico



Fotovoltaico



Batterie



Frigorifero elettrico

Cooling tower



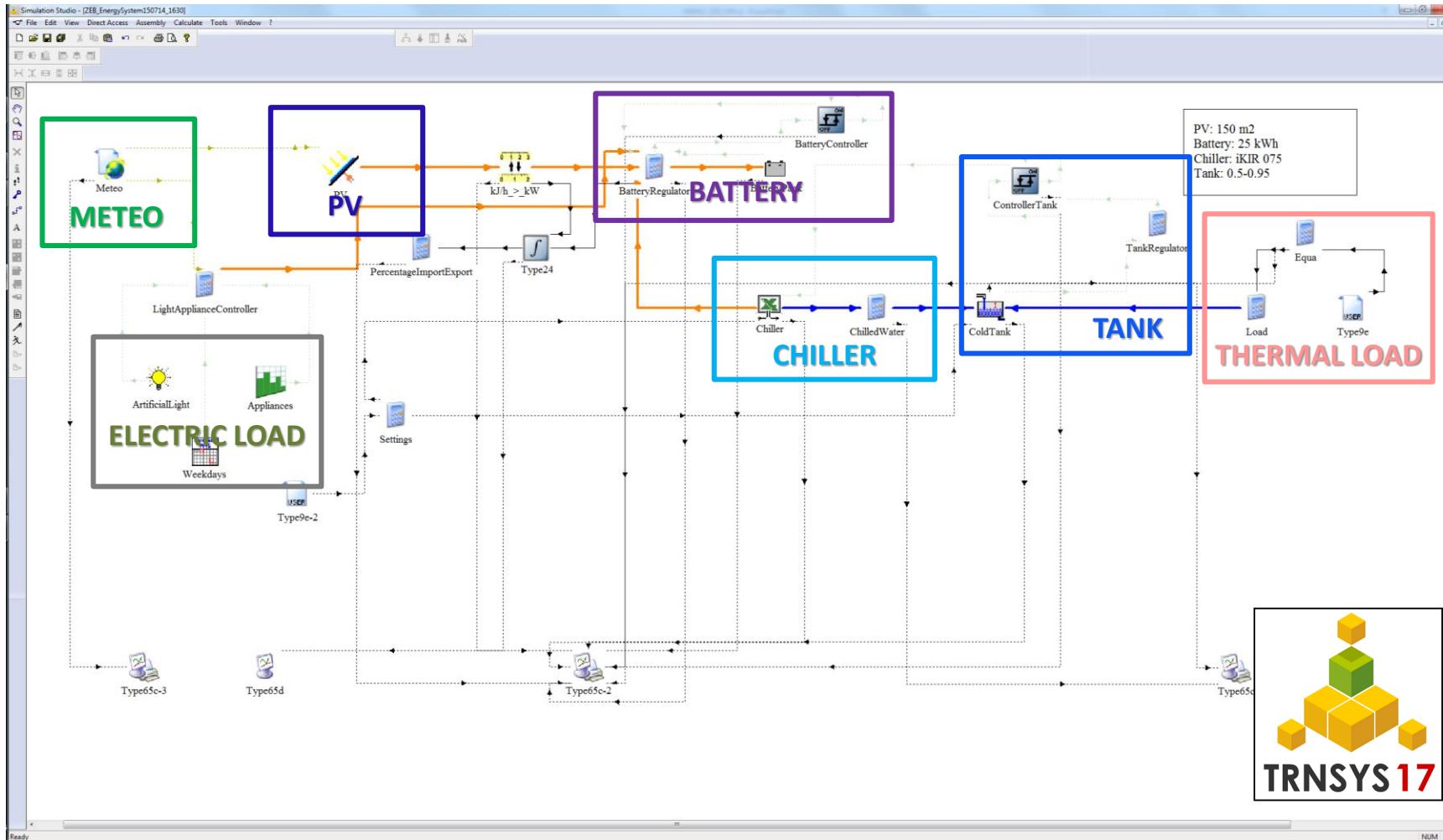
Air cooler



Groundwater



# Modellazione e simulazione

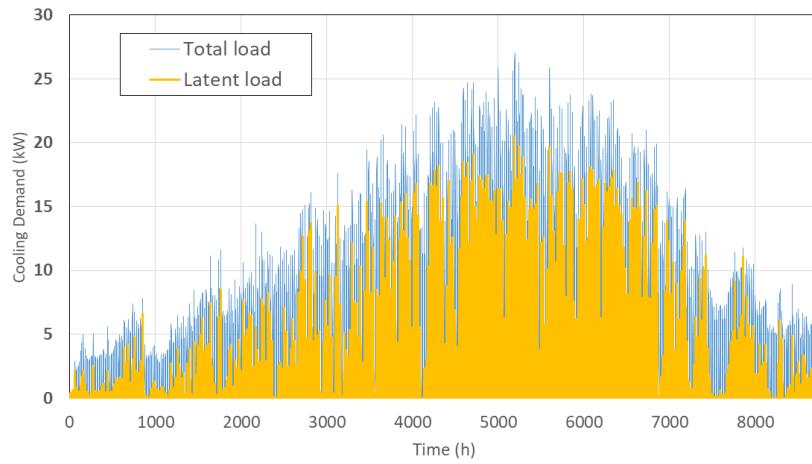


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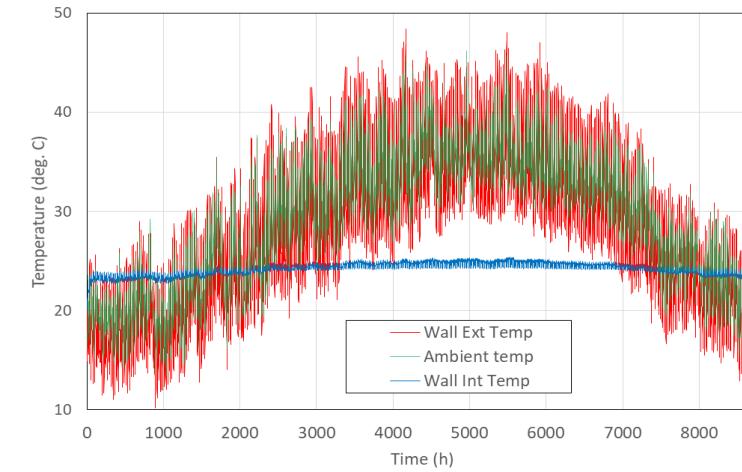
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of Engineering  
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# Modellazione e simulazione

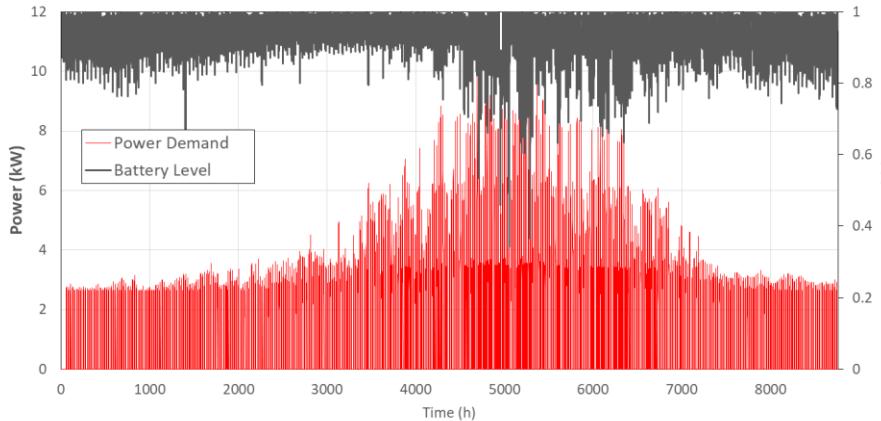
## Carichi termici



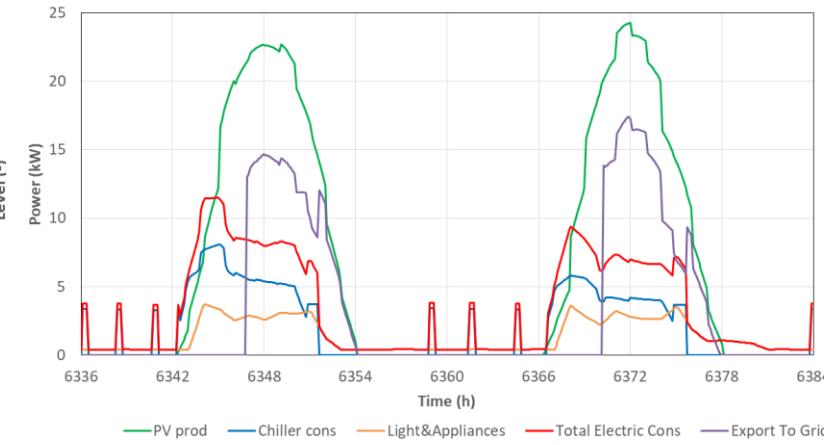
## Temperature di parete



## Fabbisogno elettrico e batterie

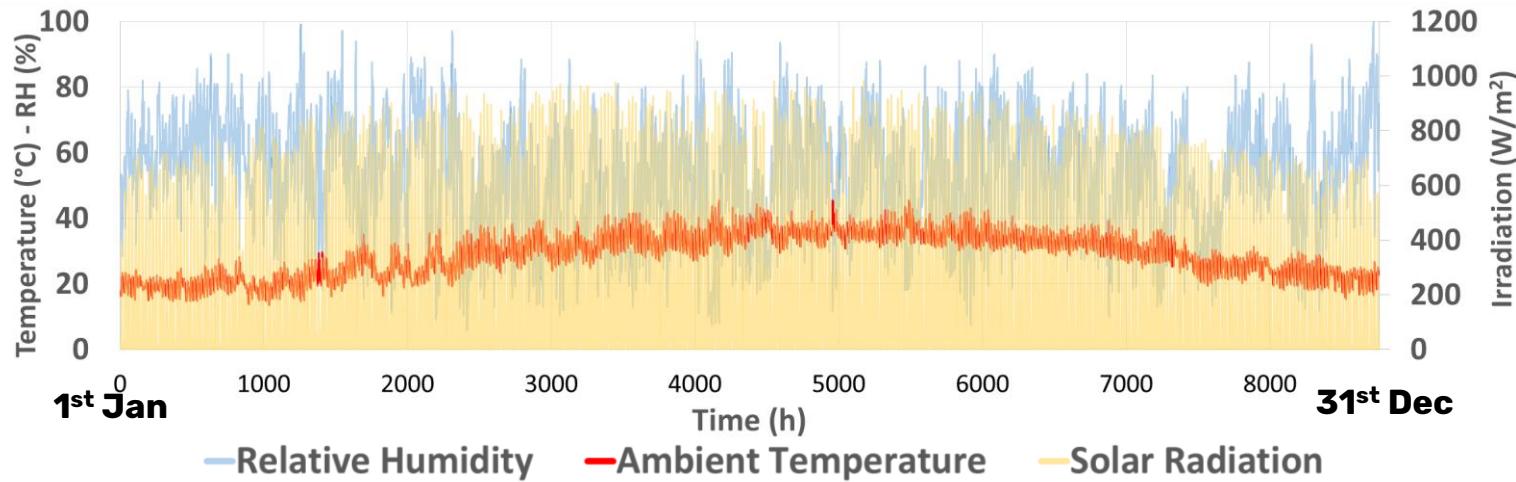


## Potenze elettriche

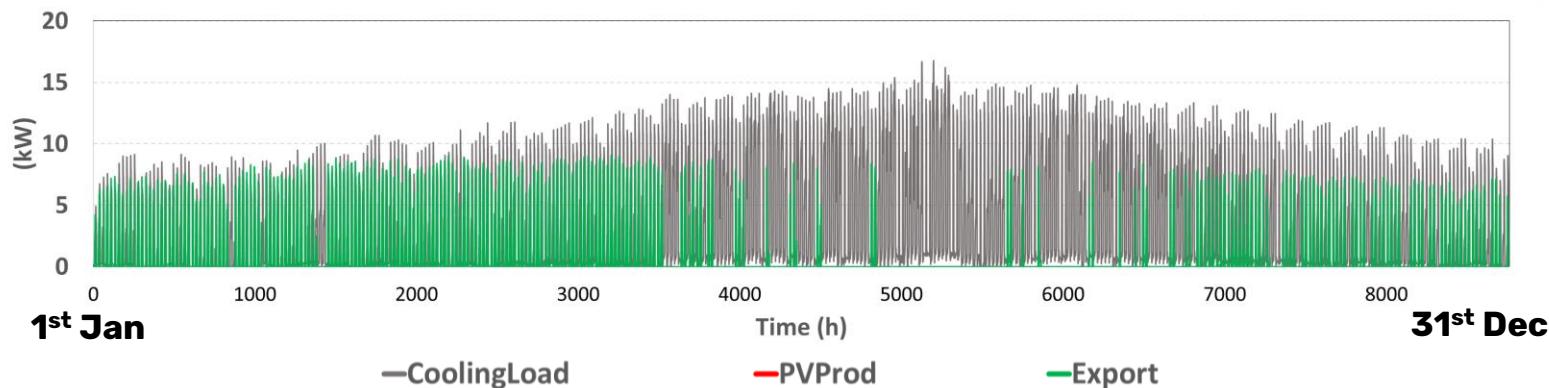


# Modellazione e simulazione

## Ambient conditions (Dubai, UAE)



## PV production

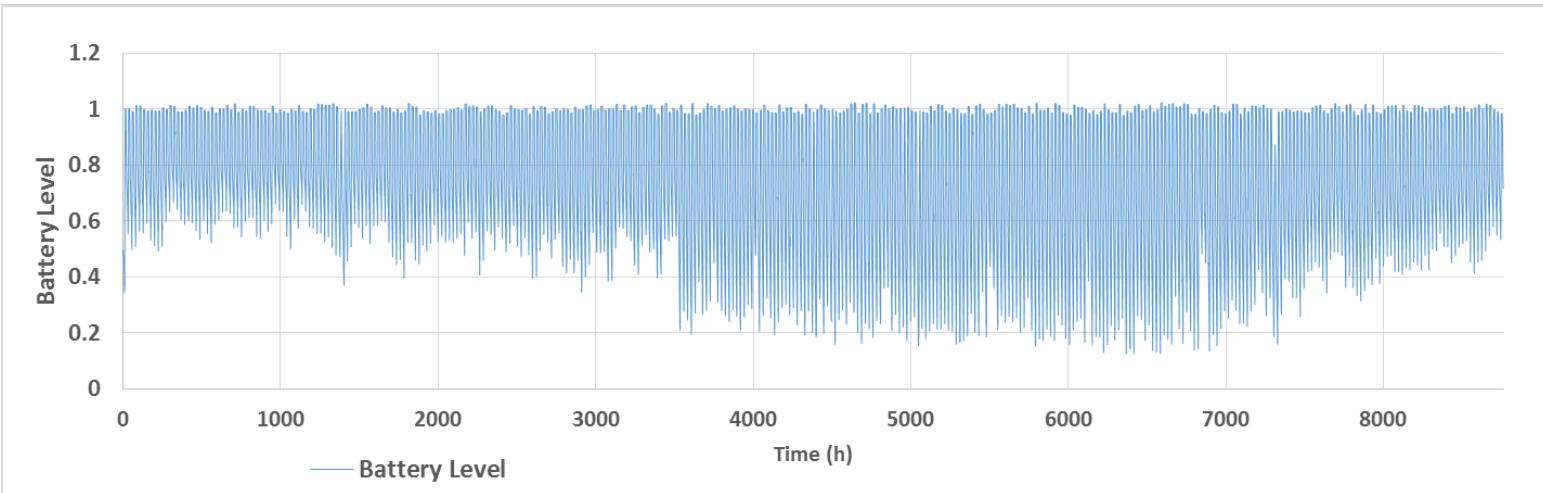


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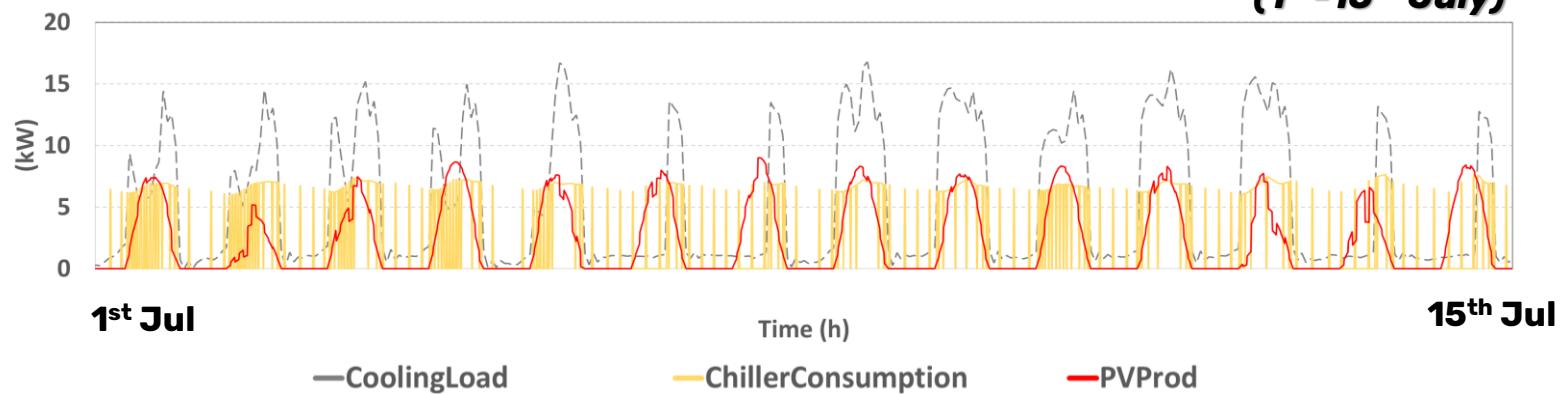
# Modellazione e simulazione

## Battery Level



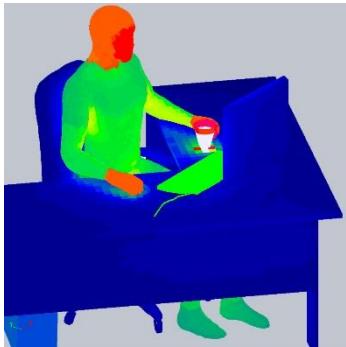
## PV production and chiller consumption

**Two weeks  
(1<sup>st</sup>-15<sup>th</sup> July)**

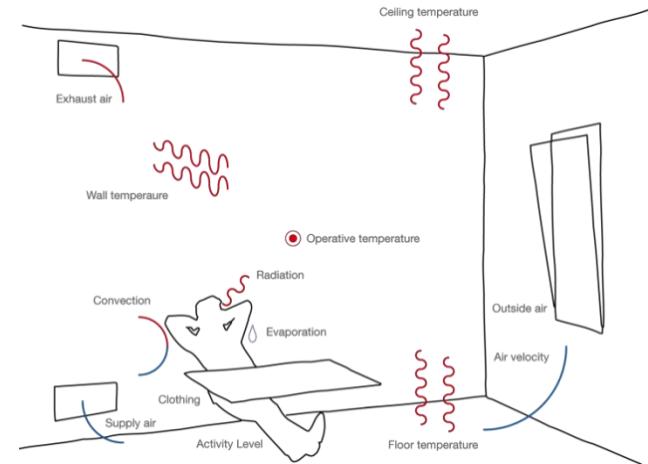


# Modellazione e simulazione

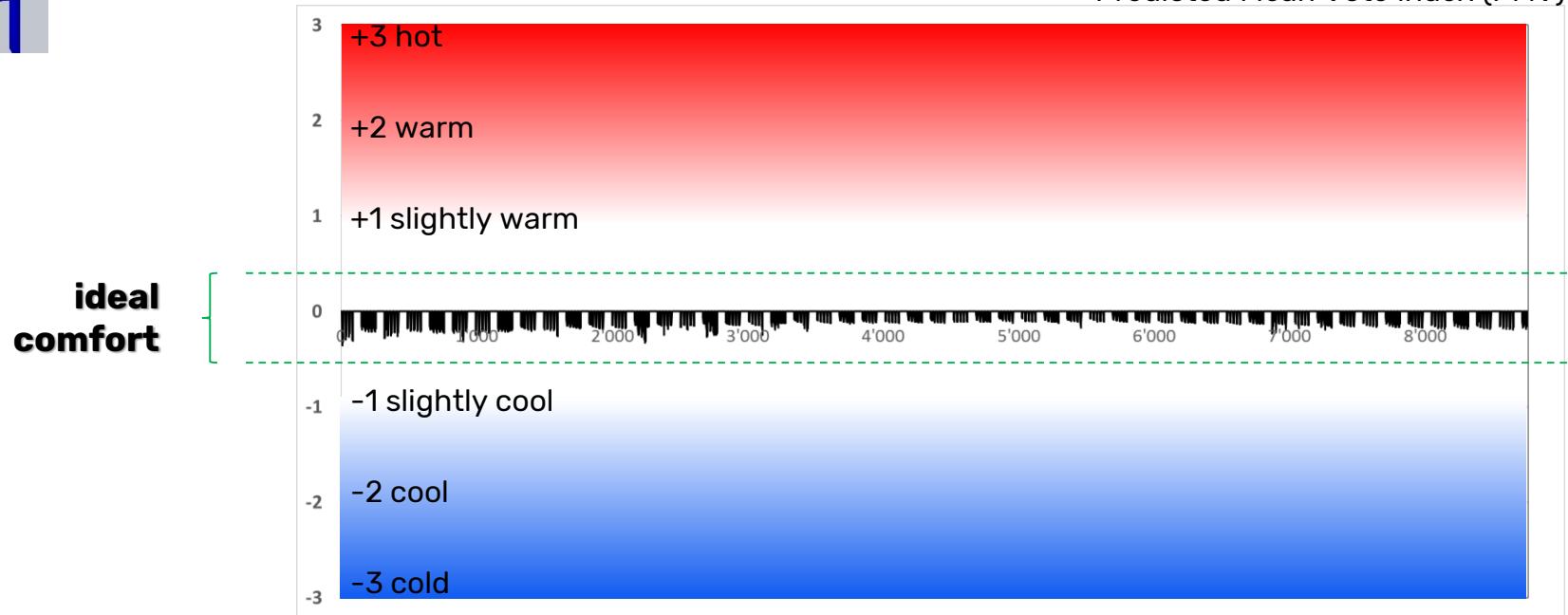
## Human Thermal Comfort



Il parametro PMV misura la percezione del comfort termico. Valori ottimali compresi tra -0.5 and +0.5.



Predicted Mean Vote index (PMV)



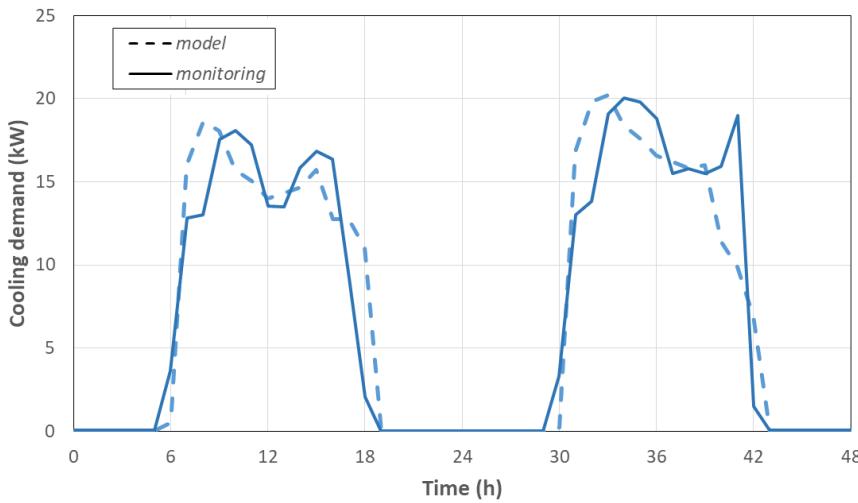
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# Modellazione e simulazione

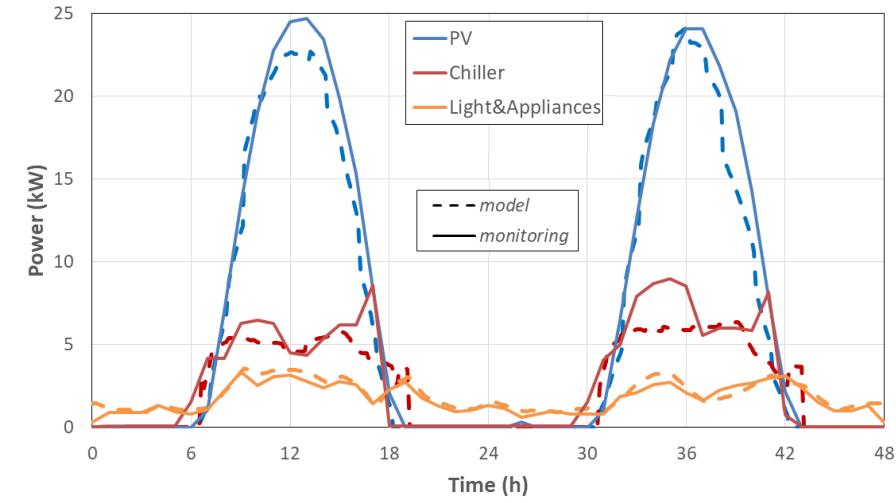
*Modello vs. Dati reali*

Cooling demand



Thermal  
envelope

Power



Energy  
system



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# Riconoscimenti



مركز محمد بن راشد  
للفضاء

MOHAMMED BIN RASHID SPACE CENTRE

“Our goal is to establish the UAE as a successful global model combining: economic growth, energy sustainability and a clean safe environment...”

Sheikh Mohammed bin Rashid



*H.H. Sheikh Mohammed bin Rashid Al Maktoum at the opening ceremony*



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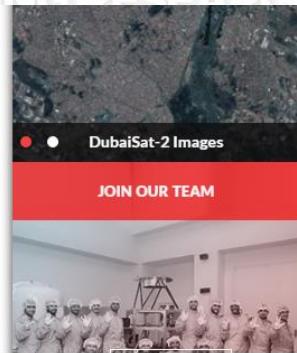
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# Riconoscimenti



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للفضاء  
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2017 MENA Green Building  
**AWARDS**



MBRSC's Sustainable  
Autonomous House wins the  
2017 MENA Green Building  
Award

May 23, 2017



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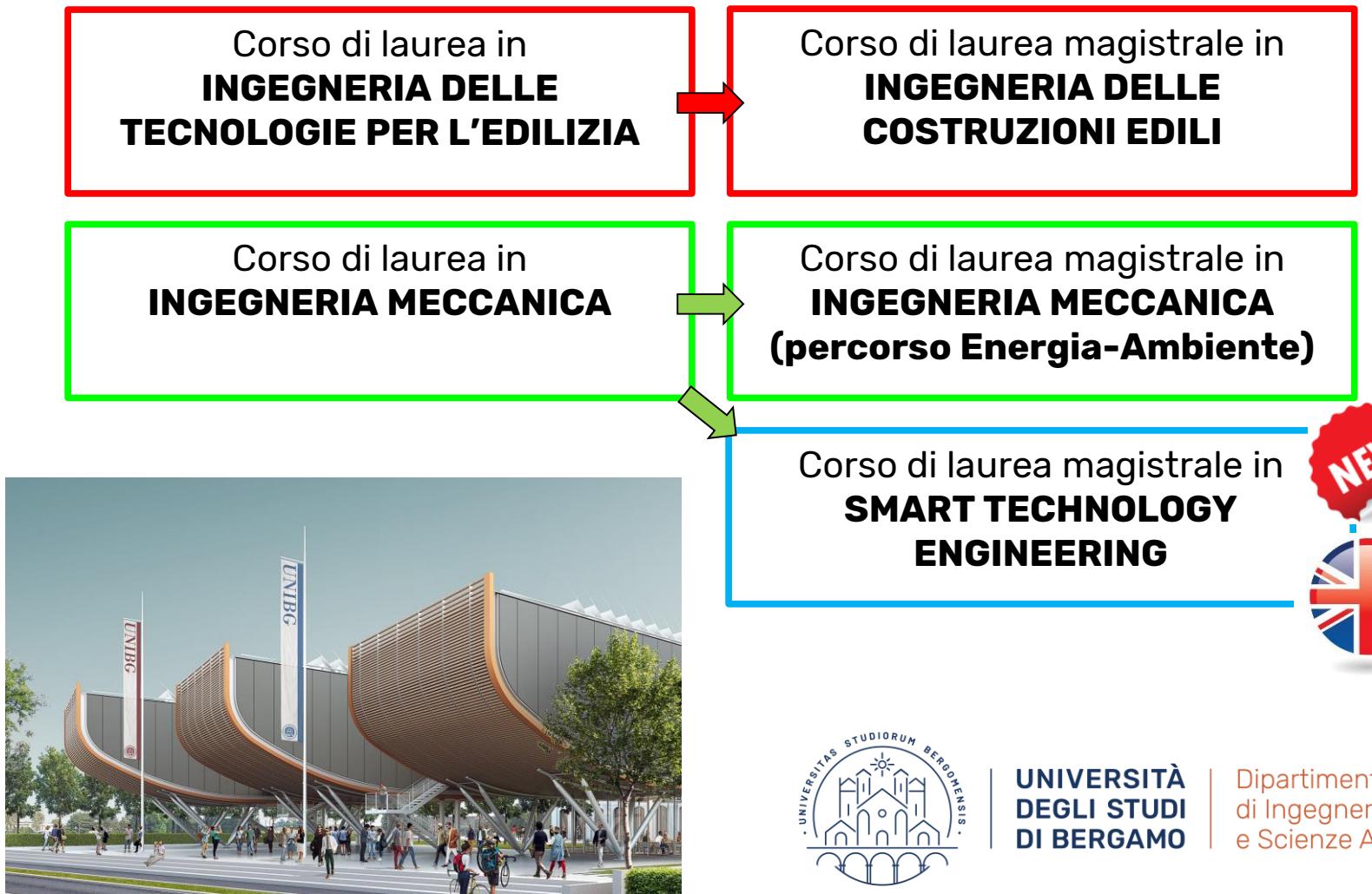
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# La formazione dell'ingegnere dell'energia e dell'ambiente



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prof.  
**Giuseppe Franchini**

ENERGY SYSTEMS  
RENEWABLE ENERGY

[giuseppe.franchini@unibg.it](mailto:giuseppe.franchini@unibg.it)

T. (+39) 035 2052 078

viale Marconi 5  
Dalmine (BG) - Italy

[www.unibg.it](http://www.unibg.it)