Energy Efficiency Guidelines for Office Buildings in Tropical Climate

Process design: from a conventional building to a highly energy efficient building

Organization of American States

Process design: from a conventional building to a highly energy efficient building

- Shape of the building: the "Extended" shapes are discarded as a considerable space within the building lacks daylight and the natural ventilation possibilities are reduced (as long as the climate allows this). The selected shape is the Long Bar, as this allows for optimal orientation and optimal solar protection of façades.
- Maximum insulation: due to the relatively low maximum temperature difference, a moderate width of insulation is selected, 2.5 cm, since it delivers the biggest demand reduction with the lowest investment.
- Efficient windows: following a similar reasoning, the option delivering the biggest energy saving at the lowest cost is chosen, that is, double glazing with air gap.

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12 parameters have been studied through a Design Builder–Energy Plus simulation.

- 1. Compactness
- 2. Global glazing proportion
- 3. Thermal insulation
- 4. Thermal mass
- 5. Glazing–to–wall ratio
- 6. Glazing type
- 7. Orientation & glazing
- 8. Shading coefficient of solar protection
- 9. Night ventilation
- 10. Roof shading
- 11. Air thermal recovery
- 12. Efficient lighting

3 parameters has been calculated

- 13. Radiant cooling panels
- 14. Photovoltaic
- 15. Solar Thermal

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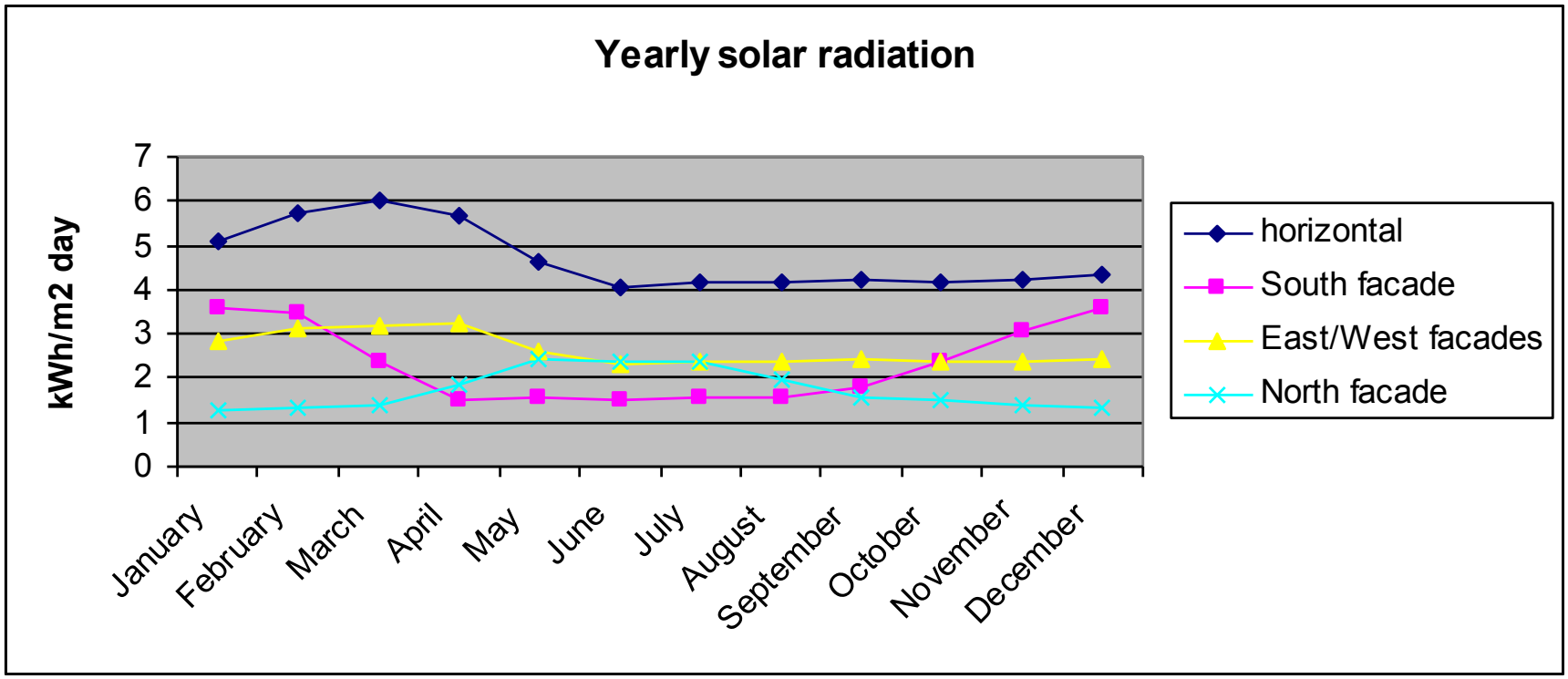
Orientation

- The orientation of the building will be South/North for the long façades.
- However, it has been rotated 20º SW in order to allow dominant Eastern winds to have a slightly higher incidence on one of the long façades to improve natural ventilation without compromising the optimal orientation advantages.



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Orientation

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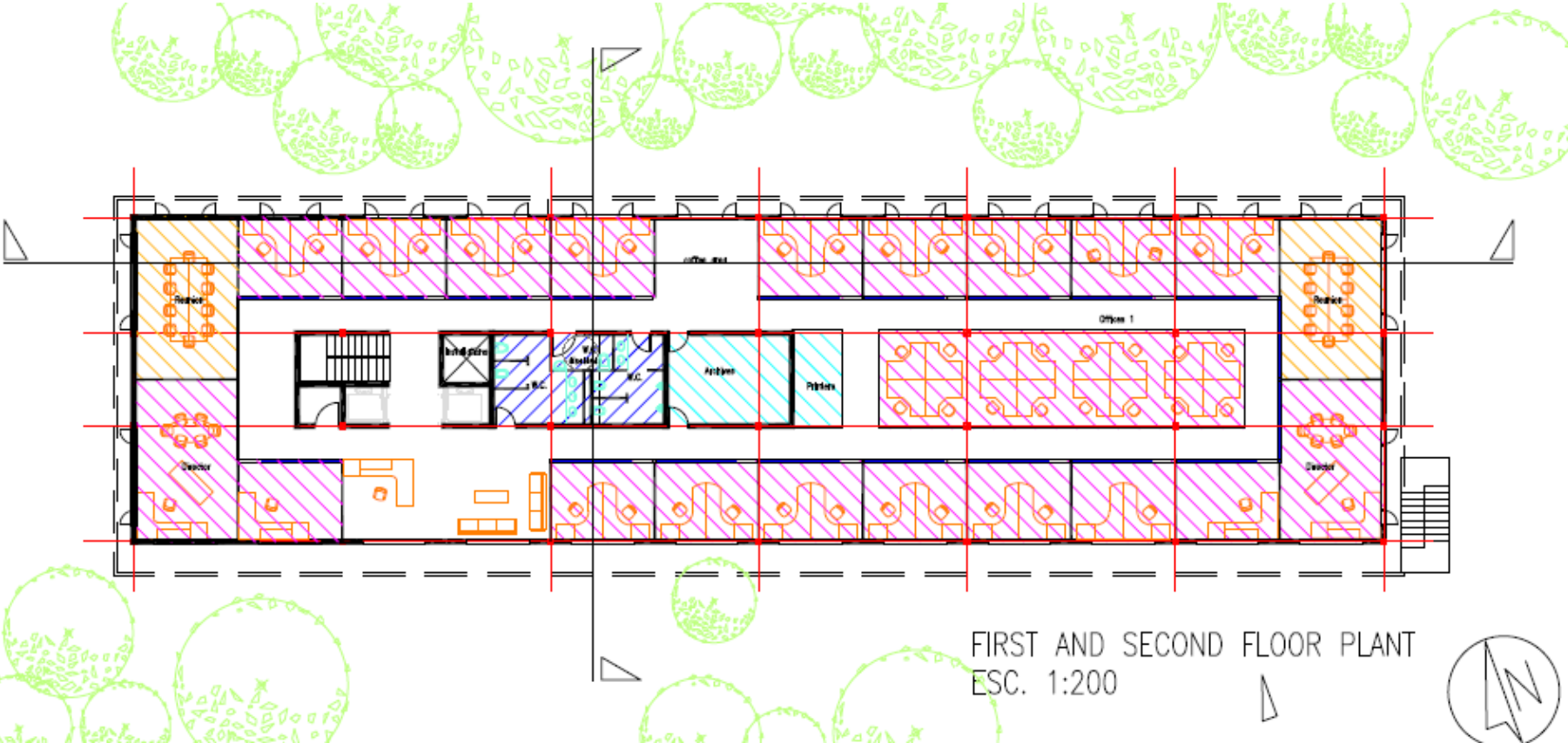
Buildings Shape

For the small (3000 sqm) and medium (6000 sqm)

- A "Bar" shape has been selected, 14 m wide, in order to provide daylighting to all workstations.
- In order to guarantee this for the medium building, it is composed of two modules, whereas the small
- Both models will have three floors above ground and an underground floor for parking purposes mainly.



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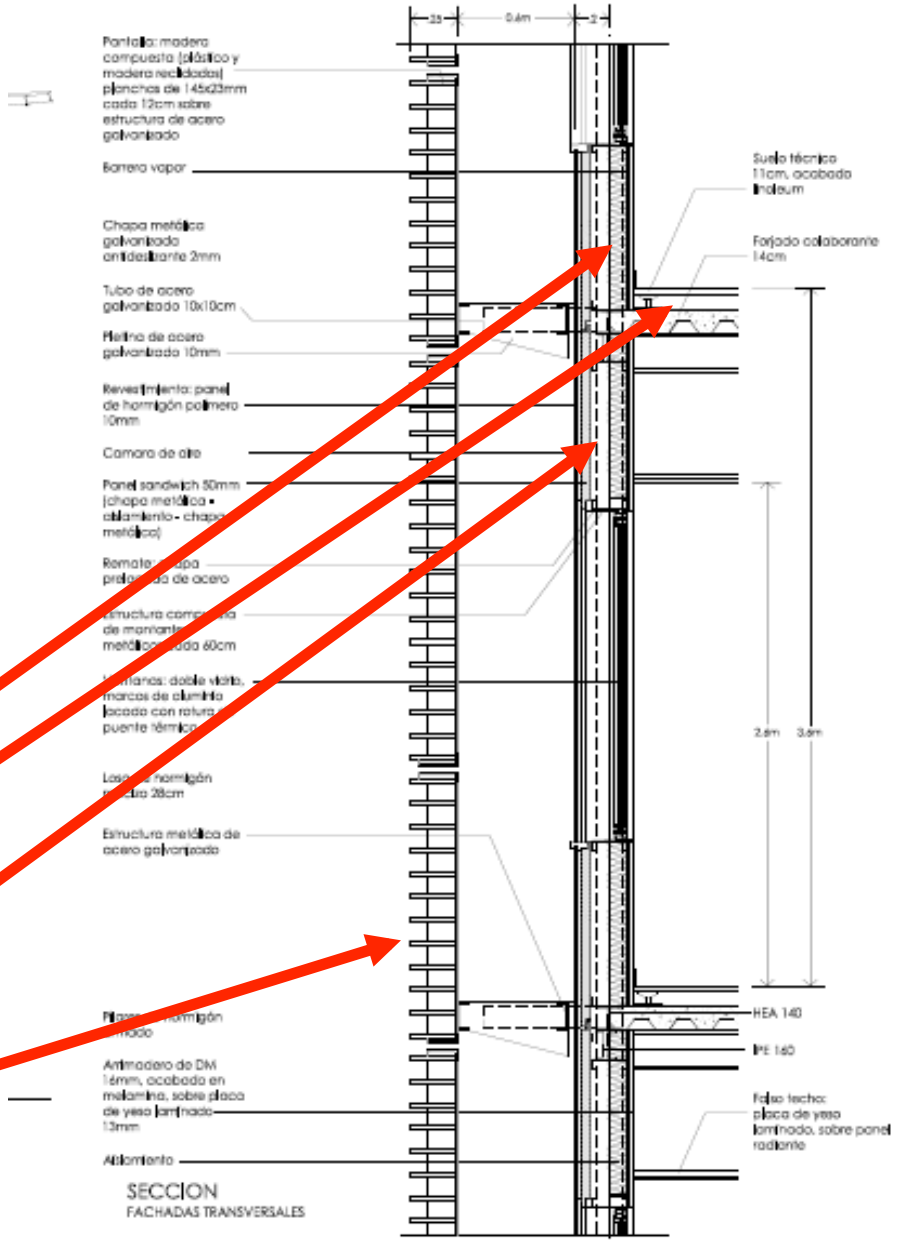
Thermal insulation

- An equivalent 2.5 cm expanded polystyrene insulation has been opted for the façades. No insulation is installed in the underground slab neither the first floor. The roof is not insulated since it is shaded and ventilated.

Thermal mass

- A low thermal mass construction is preferable. The simulations have been performed with a 2.5 cm wide layer equivalent to concrete.



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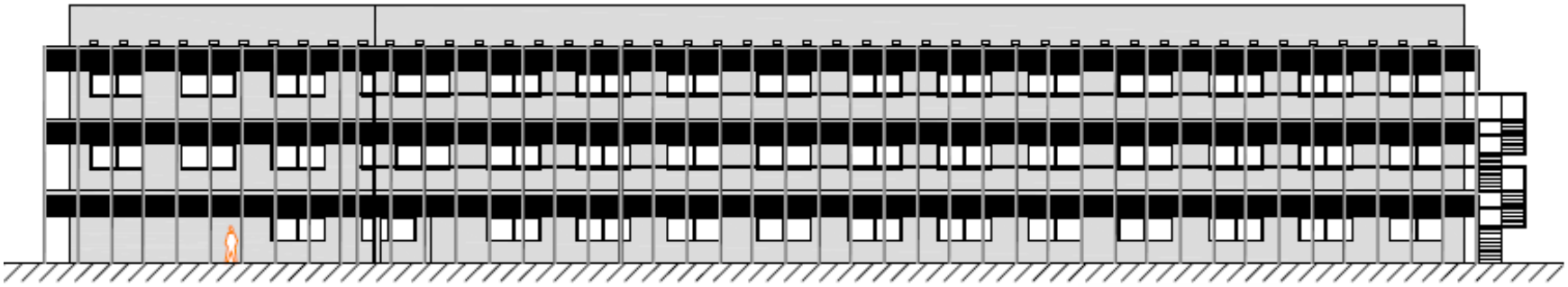
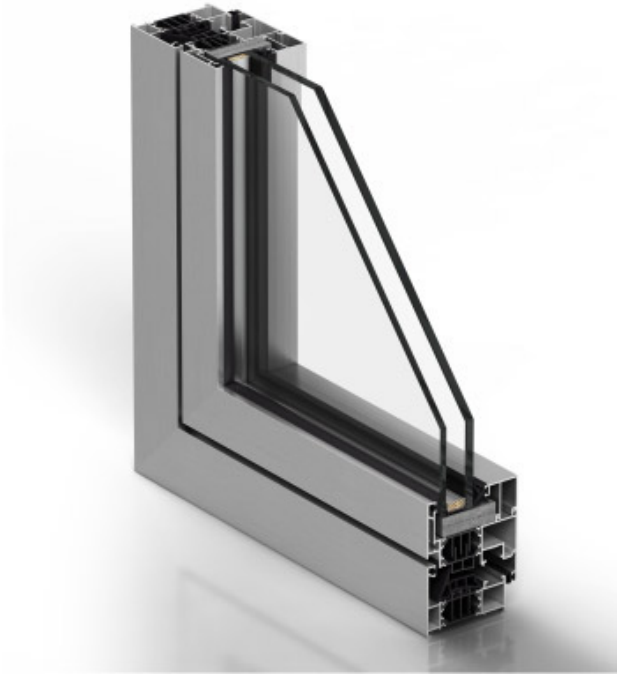
- **Windows**

- The window to wall ratio is 20% for all facades



- The double glazed windows will have a metallic frame with thermal bridge break and an air gap between the two panes.



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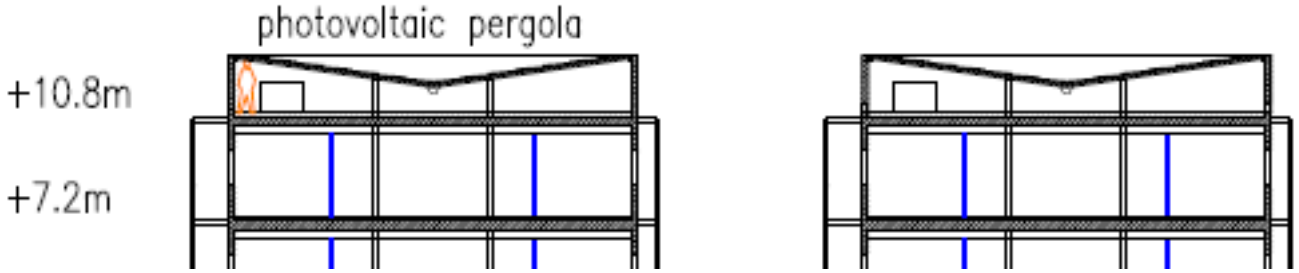
Roof

- A photovoltaic pergola serves as solar protection for a great part of the roof, preventing direct solar incidence on it and also allowing a good ventilation.

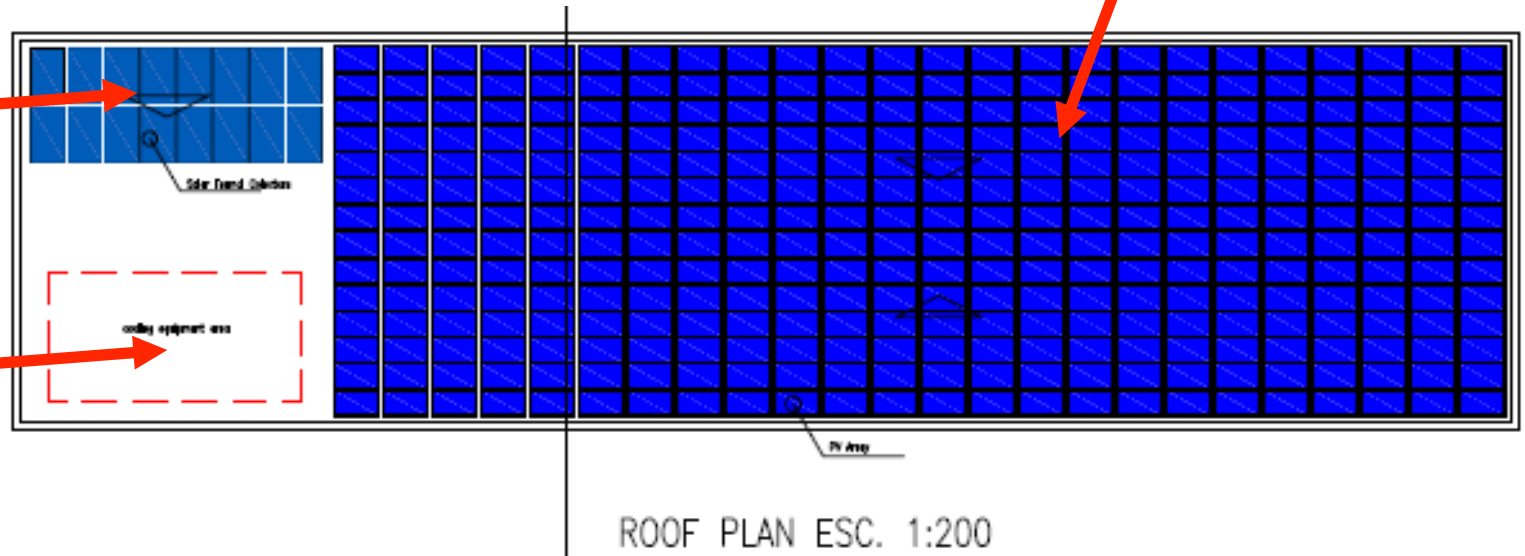


PV pergola

- Some space in the roof will be used to install the HVAC equipment. In such area the roof floor would be floating and ventilated

Solar thermal collectors

HVAC equipment



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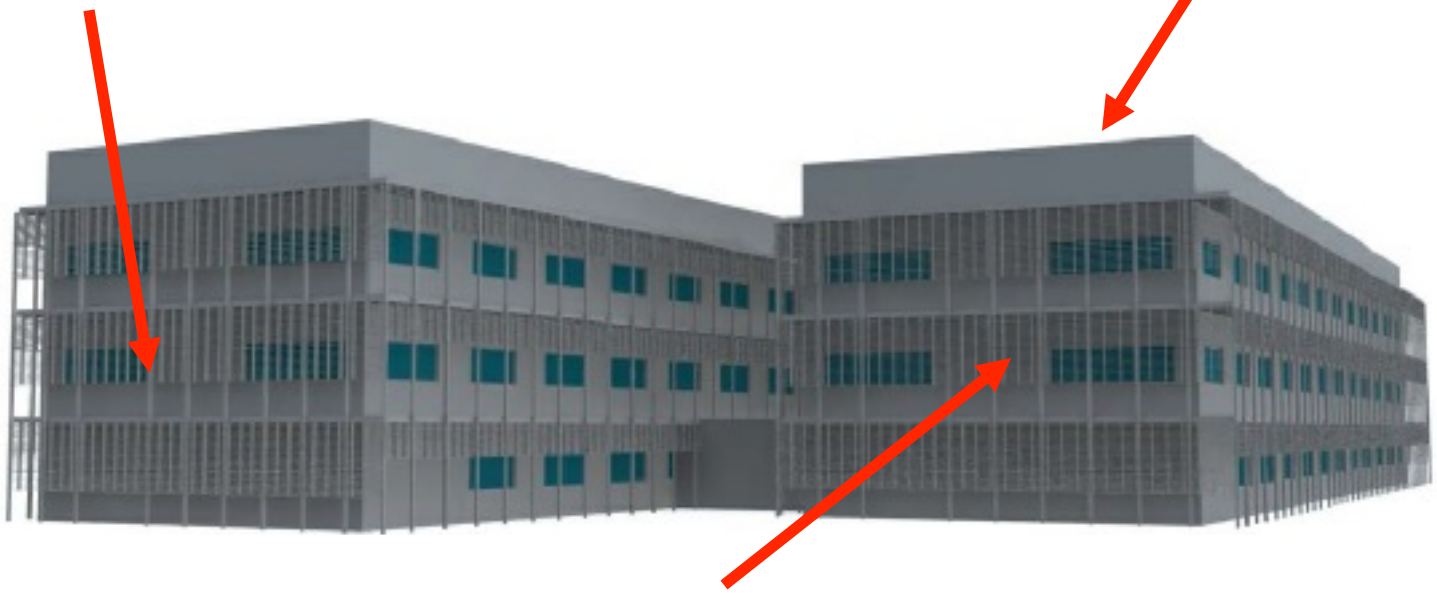
Solar Protection

- All façades will have solar protection for the windows. Different strategies will be used for East/West, South and North façades.

East / West facades: threedimensional vertical and horizontal louver protection

Roof shading: PV pergola



South/North facades: 1.2 m totally opaque overhang as a continuation of the floor

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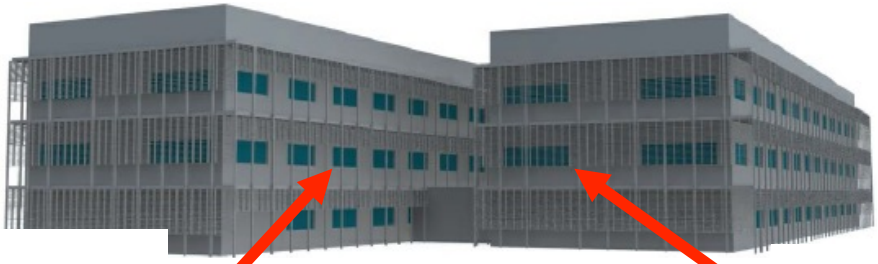
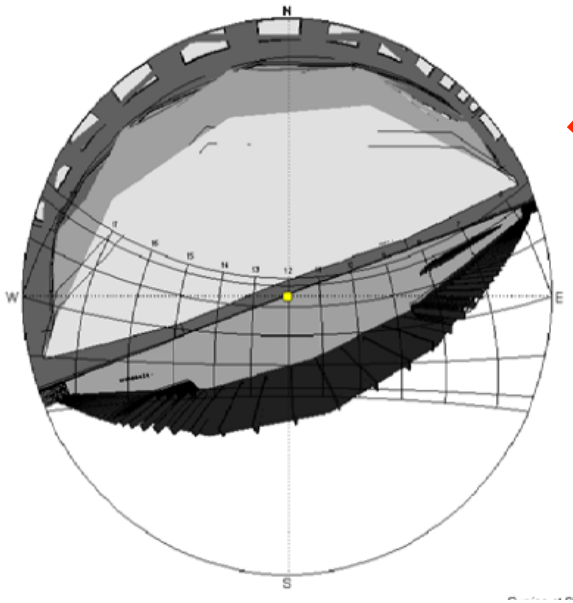
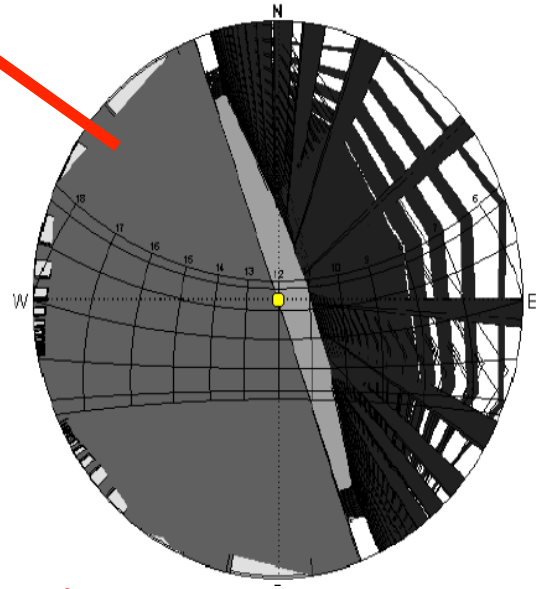
Solar shading diagram

- These diagrams show the direct solar radiation over the windows (1,1 m height) and objects that obstruct it. The image is calculated at the worst year day





South facade



East / West facades:

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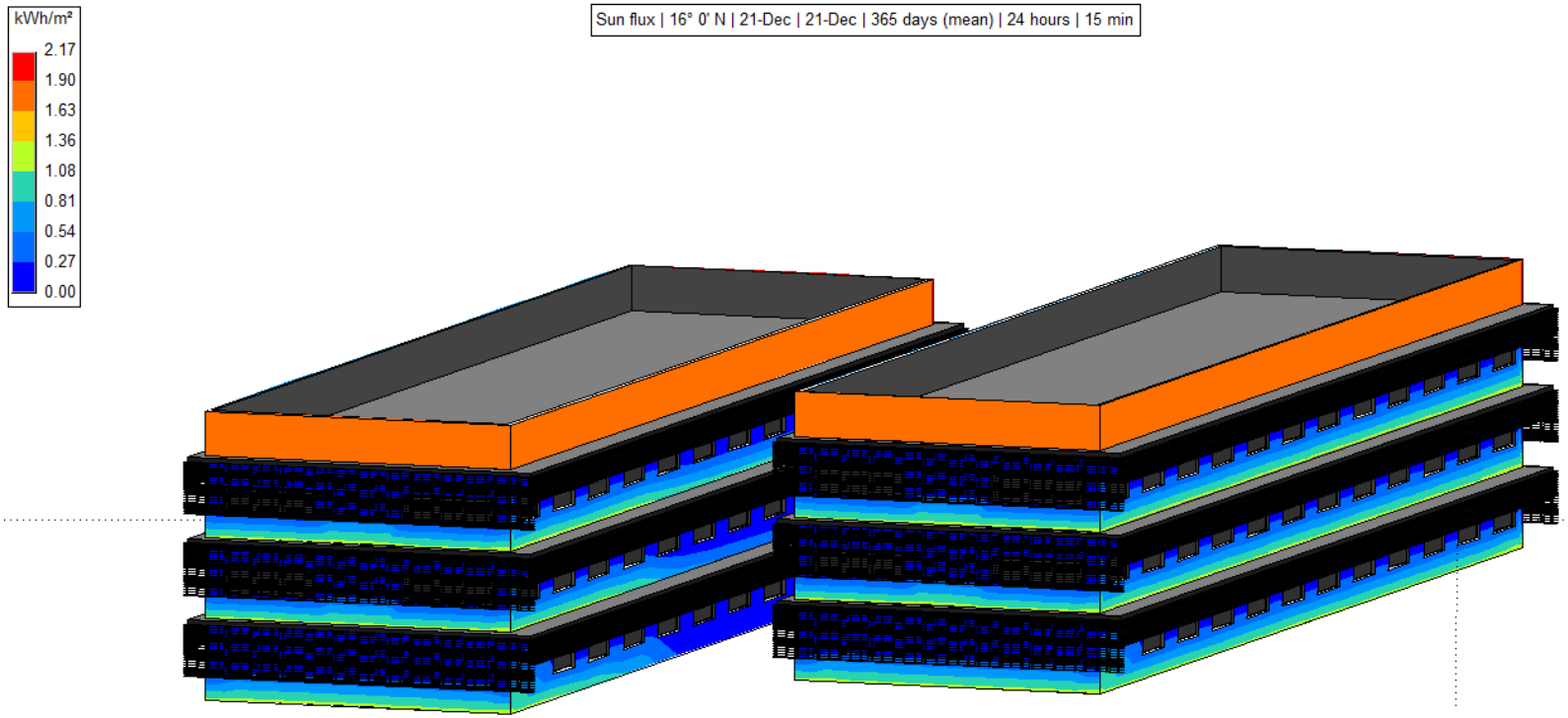
Solar shading

- The image show the result of simulations of solar incidence on façades, over the year.
- The color scale corresponds to different values of average daily solar radiation, in kWh/m2.
- The red color is the highest daily average radiation and the blue is the lowest.



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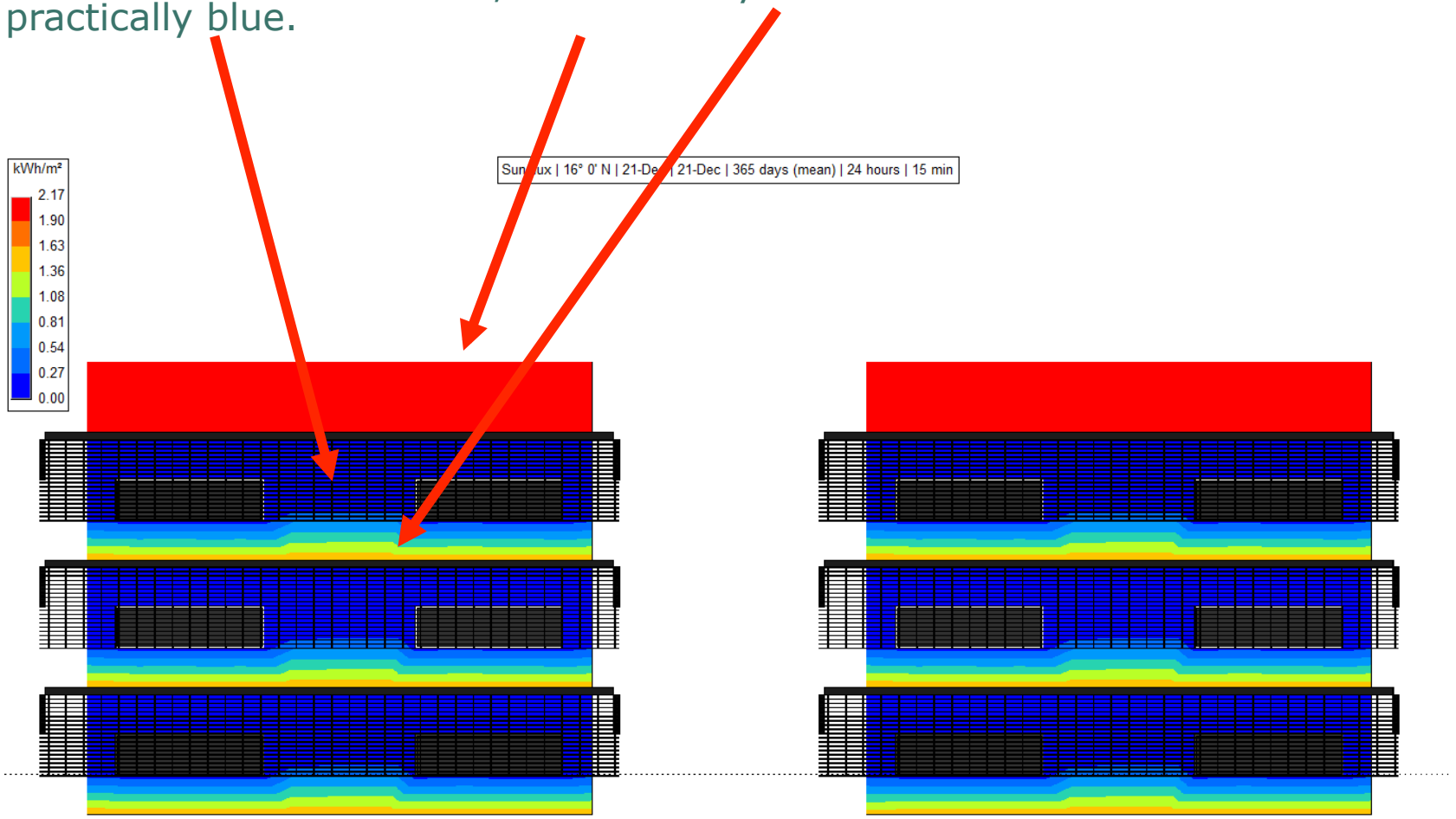
Solar shading

- East façade: the average daily radiation is much higher over the unprotected wall element over the roof, with red or yellow color and the window areas are practically blue.



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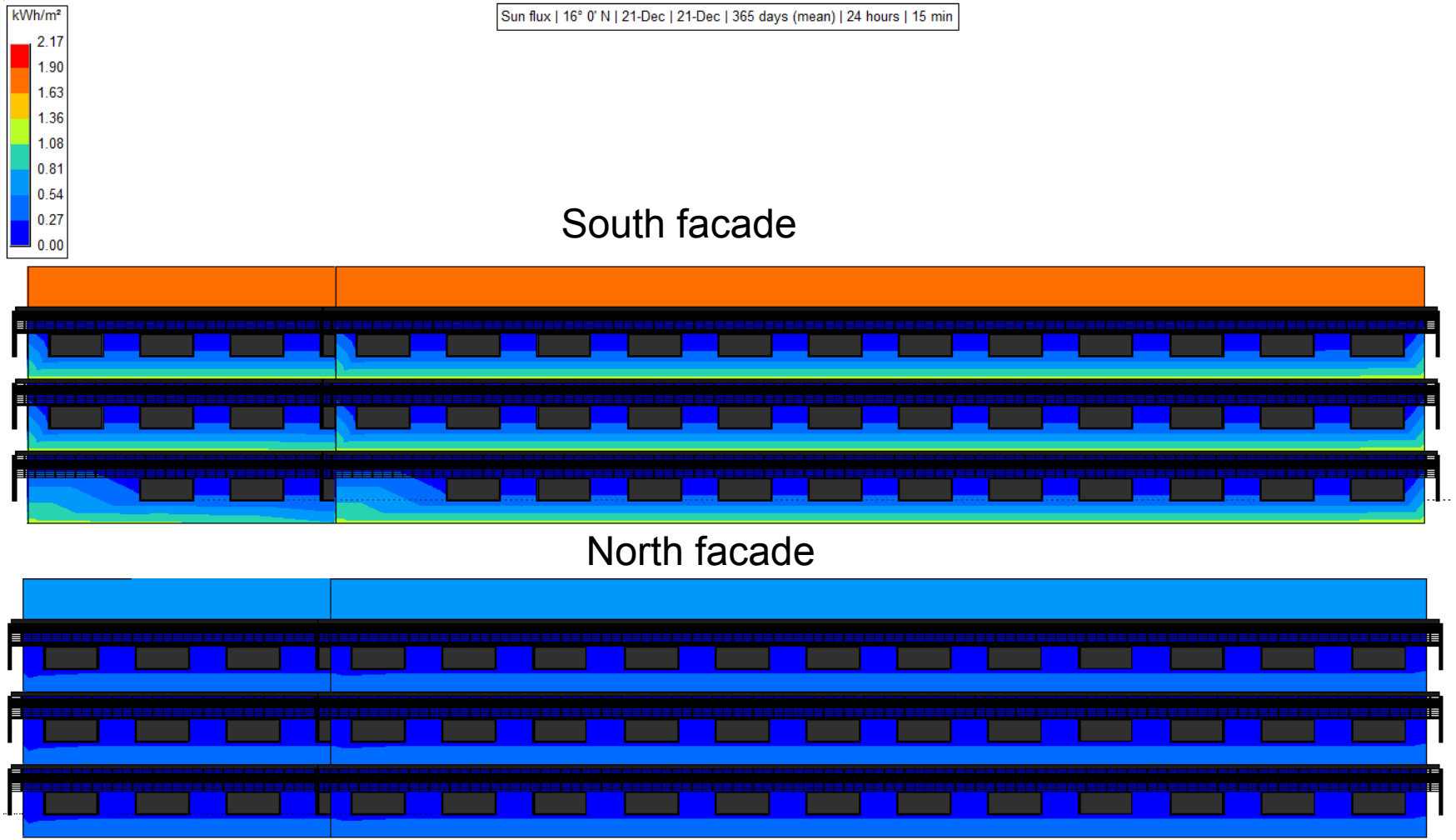
Solar shading. South and North facades

- A 1.2 m totally opaque overhang as a continuation of the floor is considered. Besides, this overhang can serve as an emergency exit corridor towards the external staircase.



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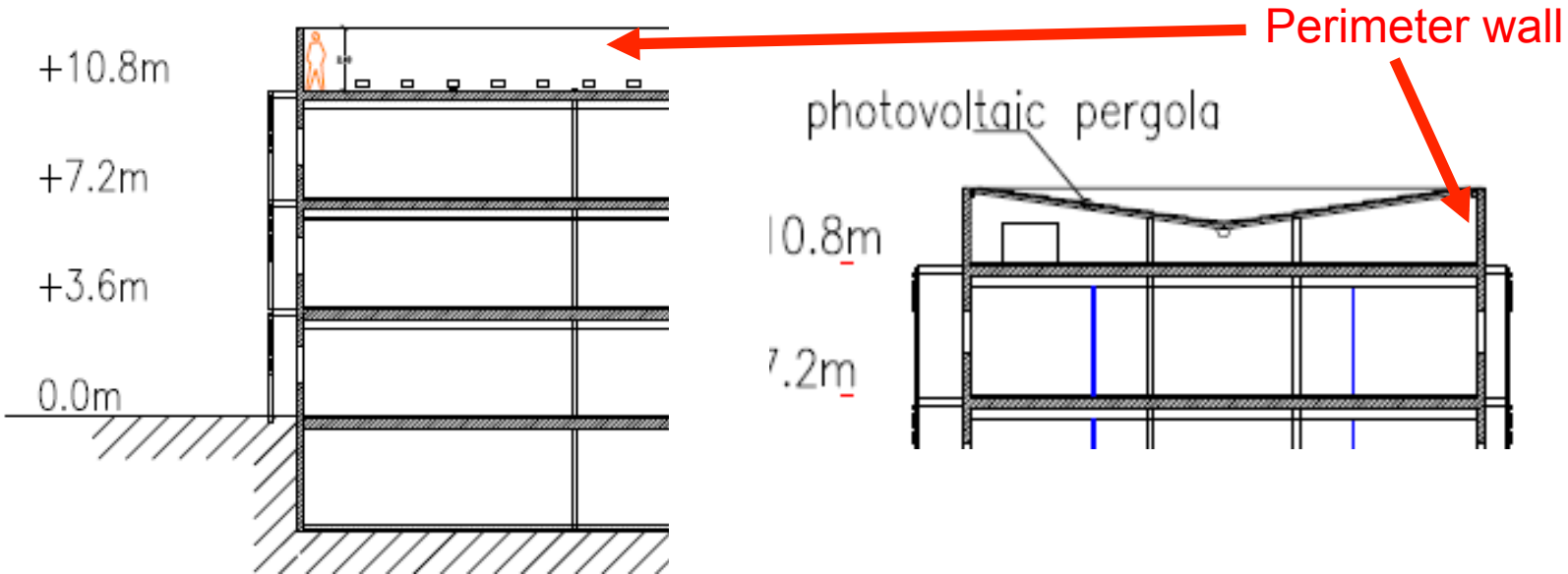
Resilience against extreme climatic events

- Structural resistance: teh design must meet the local standards and regulations;
- Façade finishes: will have to be certified for use in zones with high hurricane risk
- The insulation layer could be installed on the inner part of the wall
- Windows will have to be hurricane rated with tempered glass
- The PV pergola will be protected from wind and flying objects by a perimeter wall exceeding the roof height.
- The external HVAC units will have protections around



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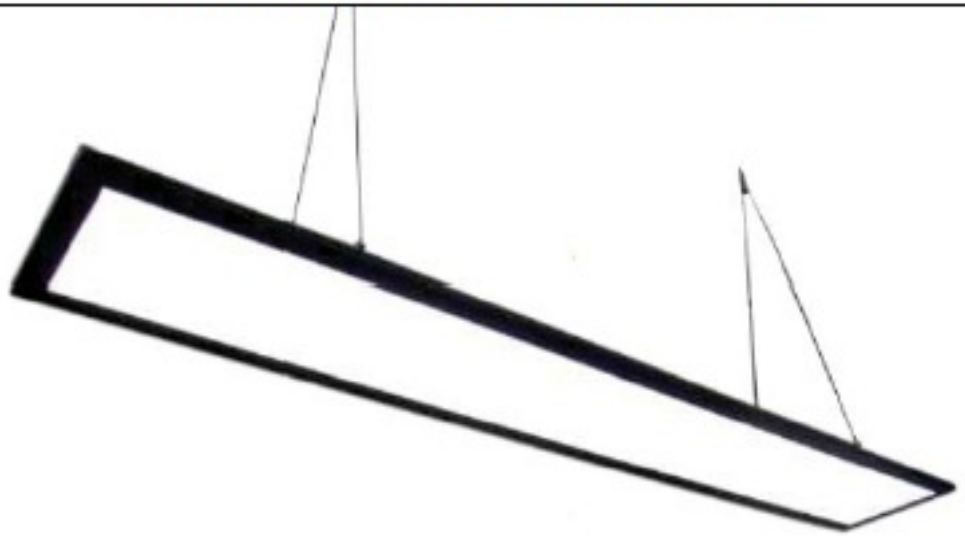
Efficient lighting

- Daylighting control will be used to regulate artificial lighting depending on available daylight.
- No skylights; all daylight enters through facades
- No workstations farer of 7 m to a window
- Internal partitions mostly transparent
- A 100% LED lighting is selected, with a target illuminance of 500 lux in workplaces, approx. 300 lux in corridors, service areas etc., and approx. 100 lux in the parking.

79 x DIALux DALLE LED 1200x200 45W BN D	35 x DIALux DALLE LED 40W BN 600x600
	

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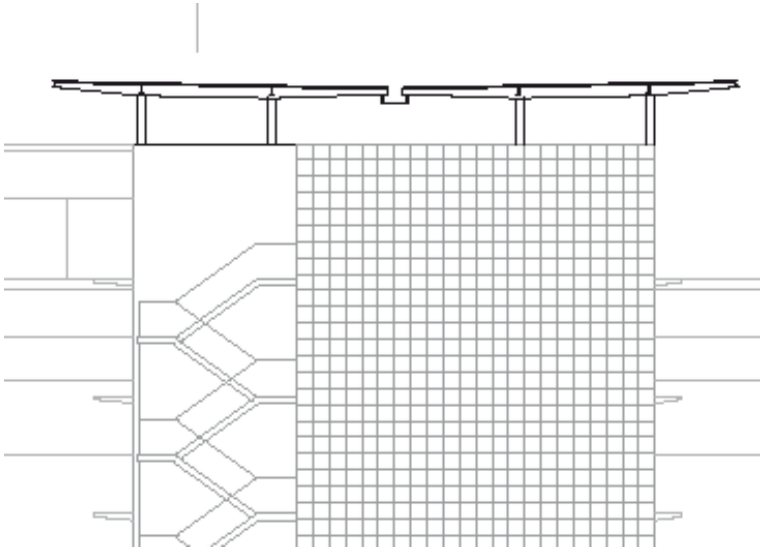
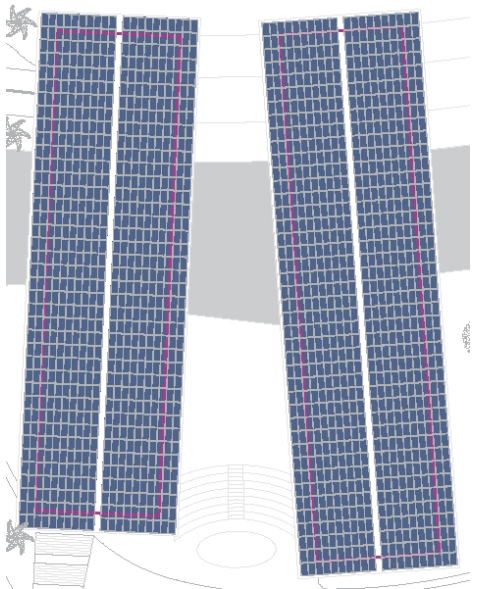
Photovoltaics

The integration of a photovoltaic (PV) generator into an energy efficient building is probably the most effective way, in terms of investment, to generate renewable energy locally. The improvements that such installation can deliver are:

- Electricity production (50 kWh/m2 of useful building area per year, for a 2 level building)
- Shading the roof (37 kWh/m2 of useful building area per year of cooling demand reduction)
- Allow ventilation of roof, increase waterproofing lifetime
- Harvesting clean rainwater : 0,75 m3/m2 of useful building area per year*





* If enough storage is available

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Solar thermal

An estimation of hot water demand has been made for both BD and EED; specifically, the areas that may have a hot water demand are the cafeteria and the dining room and kitchen for the medium sized building and only the cafeteria for the small building

EE Building	Useful surface*	Staff	Estimated Hot Water consumption	
	m2	people	l/person per day	l/day
Medium Building	4,586	328	8	2,624
Small Building	2,268	140	2	280

Small EED building

EE Building	Hot Water demand		Solar Thermal system			
	HW consumption	HW demand	Surface	estimated production		Solar fraction
	l/day	MJ/year	m2	MJ/year	kWh/year	%
Medium Building	2,624	134,168	36	94,740	26,309	72
Small Building	280	14,317	4.5	11,131	3,091	78

Medium EED building

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Models	Lighting	Cooling (electricity)	Cooling (Thermal)	Total (ligth.+cool /therm)	Total (light.+cool. Elect.)	Improvement
Baseline*	37,9	128,2	320,5	358,4	166,1	Ref (0%)
EEB**	54,0	111,7	279,3	333,3	165,7	0,2%
EEB**+TR	54,0	93,7	234,2	288,2	147,7	11,1%
EEB+TR+LC	31,3	81,3	203,2	234,5	112,6	32,2%
EEB+TR+LL	20,3	76,6	191,4	211,7	96,8	41,7%
EEB+TR+LL+LC	11,7	71,7	179,3	191,0	83,4	49,8%
EEB+TR+LL+LC+PV	11,7	71,7	179,3	191,0	17,9	89,2%
EEB+TR+LL+LC+PV+ST	11,7	71,7	179,3	191,0	16,5	90,1%

* with light control. ** without light control

EEB: Energy Efficient Building

TR: Thermal recovery

LC: Lighting Control

LL: LED lighting

PV: Phtovoltaics

ST: Solar Thermal

COP: 2,5

Thank you

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