

## PV-Electricity for Cooling Systems in Southern Countries – Comparison with Absorption

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## BRISA – “Freeway” Control Center

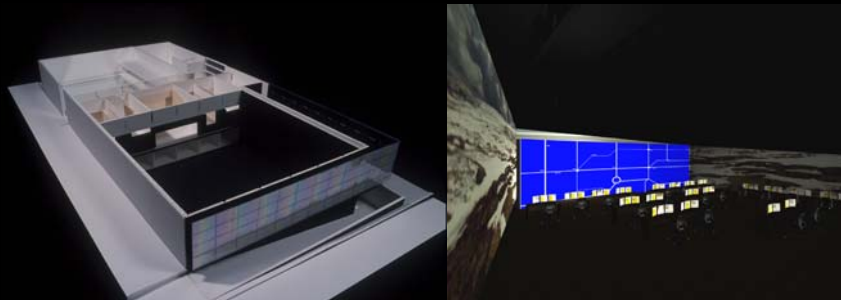
660 m<sup>2</sup> Solar thermal collectors + Absorption Chiller

The new road traffic control center for the Portuguese company *BRISA* combines high indoor climate control standards with low environmental impact.

The building design brief demanded for a fully closed building skin attaining an undisturbed environment in the large (400m<sup>2</sup>) road traffic control room.

The harsh acoustic environment from an adjacent high traffic road “pushed” building openings towards the North, freeing the remaining façade orientations.

In this scenario the design team searched for alternative uses for a building skin freed from the demand of insuring natural light and air penetration.

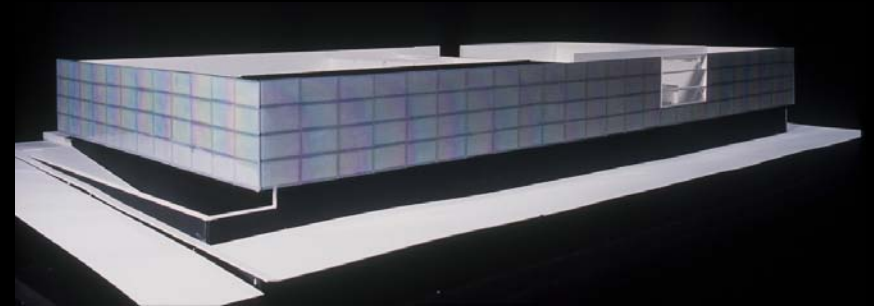


This search resulted in large solar thermal energy collecting surfaces being installed in the façade, using the local climate's high solar availability.

These surfaces perform several tasks:

- thermal energy collection for the cooling and heating system
- shading of the building external skin
- improvement of the acoustic insulation.

The cooling potential of the solar collecting surfaces was used by installing a single-effect absorption cooling chiller.





## Description of the main system components

The climate control system can be divided into two subsystems:

collection-storage of energy  
 heat exchange with the space (using ventilation air).

The energy collection and storage system is composed by:

- Solar thermal collectors (divided into four groups: East, West, South, Roof).
- Three energy storage tanks (one for cold water and two for warm water)
- One absorption chiller with dedicated cooling towers
- One backup standard reversible chiller

The heat delivery/removal and ventilation system is composed of:

- Displacement ventilation system in the traffic control room and adjacent offices
- Radiative, free cooling, system in the ceiling slab of the main control room
- Mixing ventilation system for all other spaces



Solar panels on the roof, this set of panels has a 7° angle towards the South (more was not possible due to architectural restrictions), also visible on the lower left of this figure the inflow plenum for the ceiling slab free-cooling system.

View of the south and East façades.



View of the East façade, also visible a portion of the north, stone covered, façade.



*Photos by Maria Timoteo.*



### Solar thermal collectors integrated in the building façade

The initial design included only vertical panels in the south façade that were used to provide space and sanitary water heating, mainly in the winter.

This initial concept was extended in the detailed design phase, including more surfaces and the capability to power the cooling system.

Total solar panel area in each vertical façade was limited by the façade area.

The number of panels in the roof was defined so that the building would be approximately self sufficient.

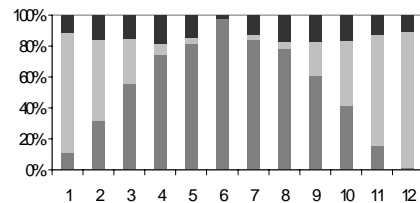
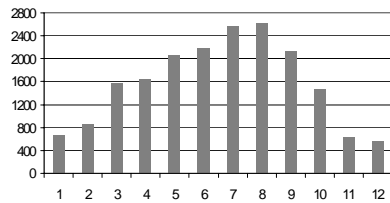
Table 2. Total area of the solar collecting surfaces used in the building skin.

Façade	Number of panels	Total area (m <sup>2</sup> )
East	48	95
West	48	95
South	91	180
Roof	148	293

### Predictions of collected energy

An existing panel design<sup>1</sup> was adapted, replacing the standard glass fixation system (an aluminum frame) by a perimeter fixation system (see figure 1).

As will be shown below, the higher values of collected energy in the spring months are essential for powering the cooling system in the summer.



Predicted total net energy collected by the panels (excludes system losses, units: MJ/day). In the horizontal axis the months of the year. (obtained using data provided by AoSo<sup>11</sup>).

Yearly variation of the predicted contribution for the three orientations used.

Light gray: South. Black: East/West. Dark gray: Horizontal.

### Single-effect absorption cooling chiller

The installation of a single-effect absorption cooling chiller allowed for the use of solar heated water (75 – 95°C) as the main power source for production of chilled water.

The other main energy exchange in the process is water evaporation in the cooling towers.

As mentioned above the system also includes three energy storage tanks:

- A small size hot water tank (25m<sup>3</sup>), to serve as the main source for the chiller.
- A large size hot water tank (60m<sup>3</sup>) to store additional solar energy whenever the smaller tank reaches maximum temperature (set to 96 °C to avoid vaporization).
- A large size chilled water storage tank (60m<sup>3</sup>).

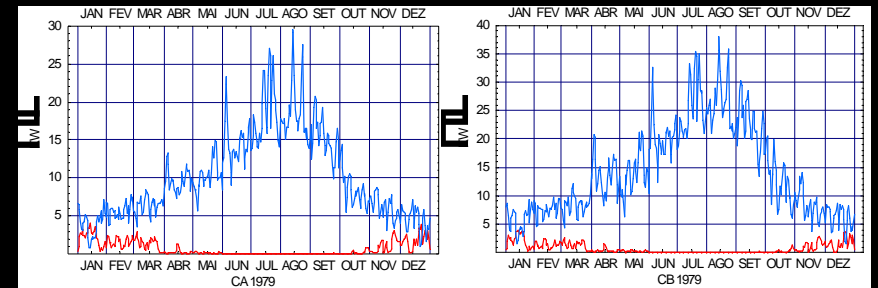
### Prediction of the building thermal loads

The prediction of the thermal loads and overall system performance in the present project was a challenging task using hourly thermal simulation based on the two Lisbon TMY weather files mentioned above.

All thermal simulations were performed using EnergyPlus<sup>[1]</sup>. Simulation proved essential in addressing the following aspects of the project:

- Accurate prediction of heating and cooling load for different ventilation and control strategies (mixing versus displacement ventilation, advantages of free radiative cooling etc).
- Optimization of the sizes of solar system and dedicated energy storage tanks.
- Definition and fine tuning of the control system.

### Results

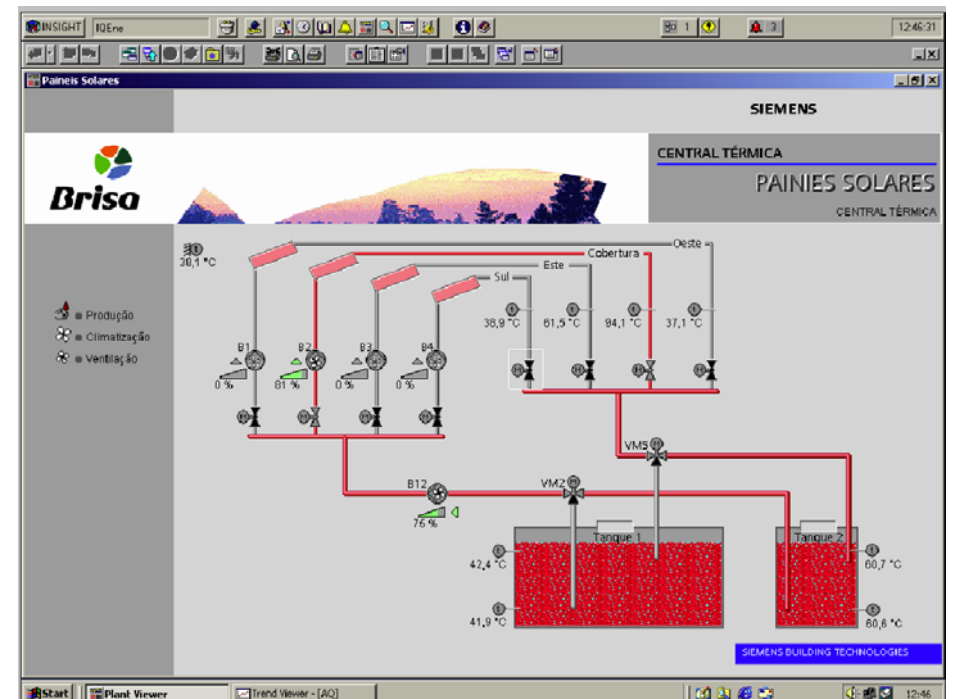


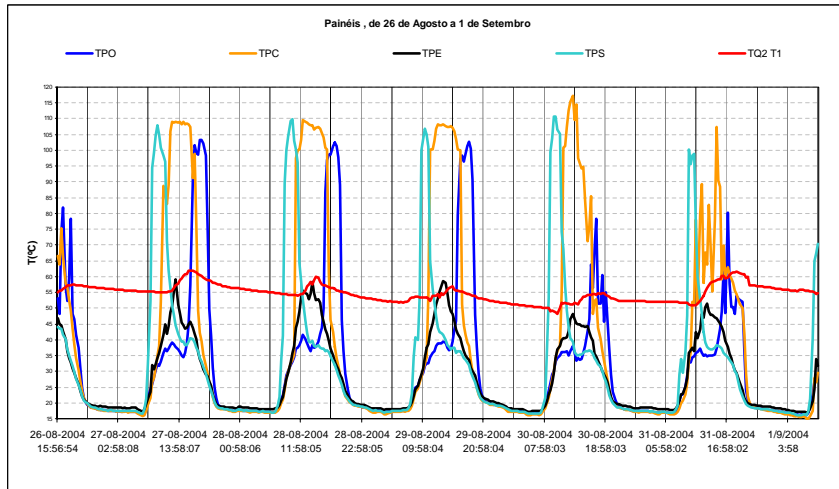
Predicted daily average value of the cooling and heating load for the two internal gain scenarios considered. In both charts, the cooling load is the line with the highest values. On the left predictions obtained using the 1979 weather file with scenario A, on the right scenario B.

Table 5. Energy consumption predictions.

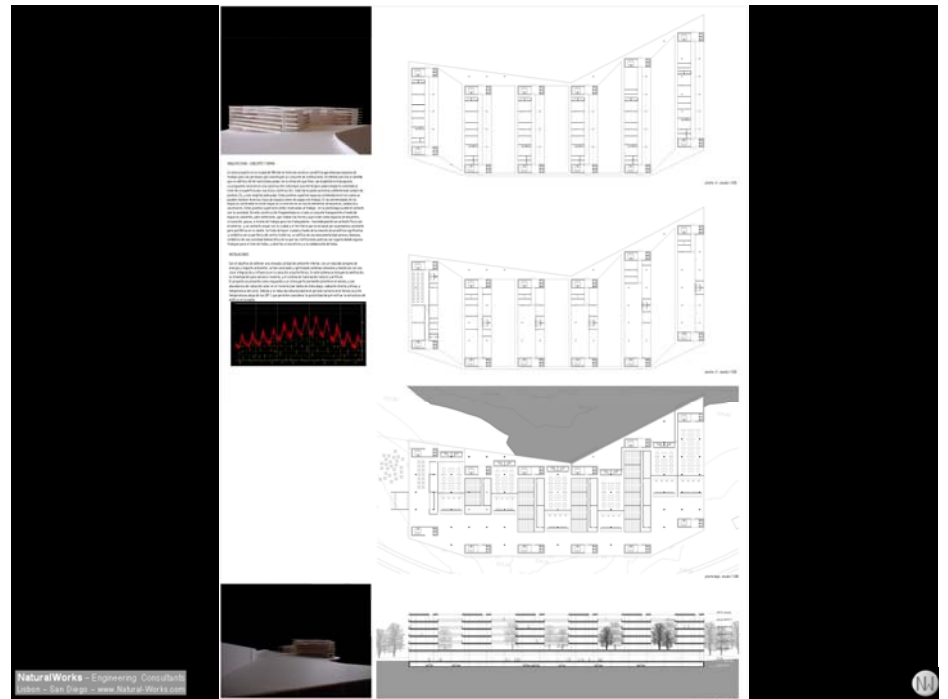
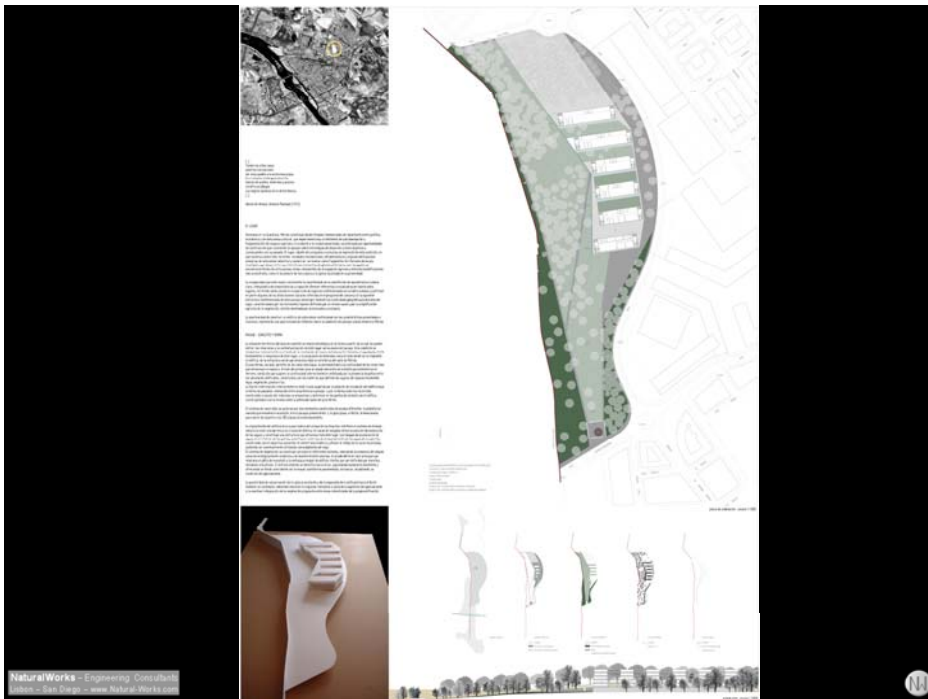
Loads Scenario	Year	Heating load (MJ)	Cooling load (MJ)	Total load (MJ)	Energy from the panels (MJ)	Backup chiller (MJ)	Percentage of backup chiller use (Chiller)
CA	1979	22971	321528	344498.6	597133	6048	2
CB	1979	22214	450532	472746.2	597133	62748	13
CA	1995	15056	383024	398079.9	598315	20160	5
CB	1995	14673	552726	567399.3	598315	151704	27

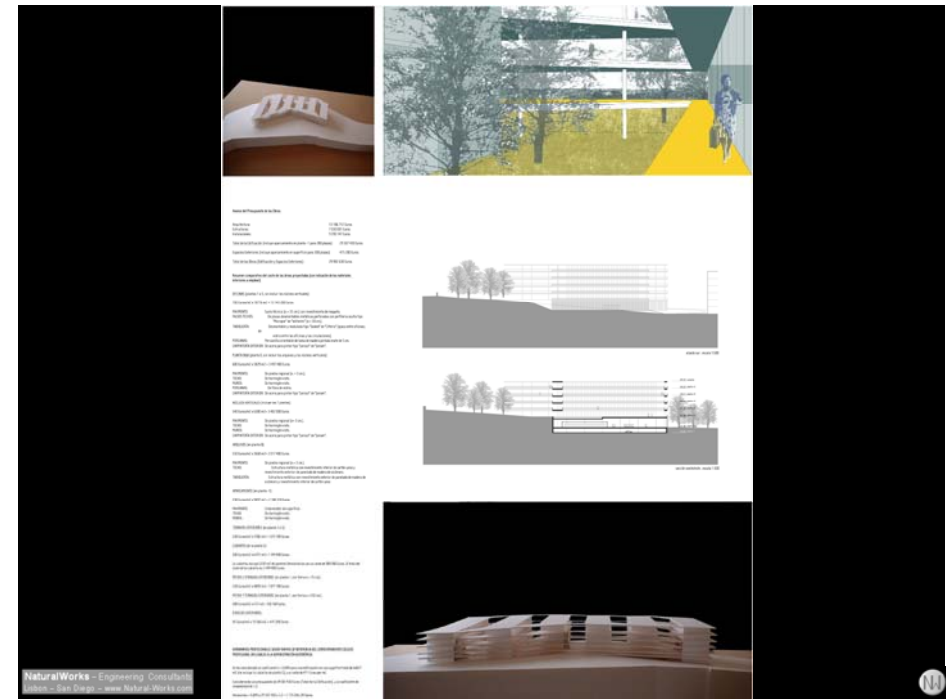
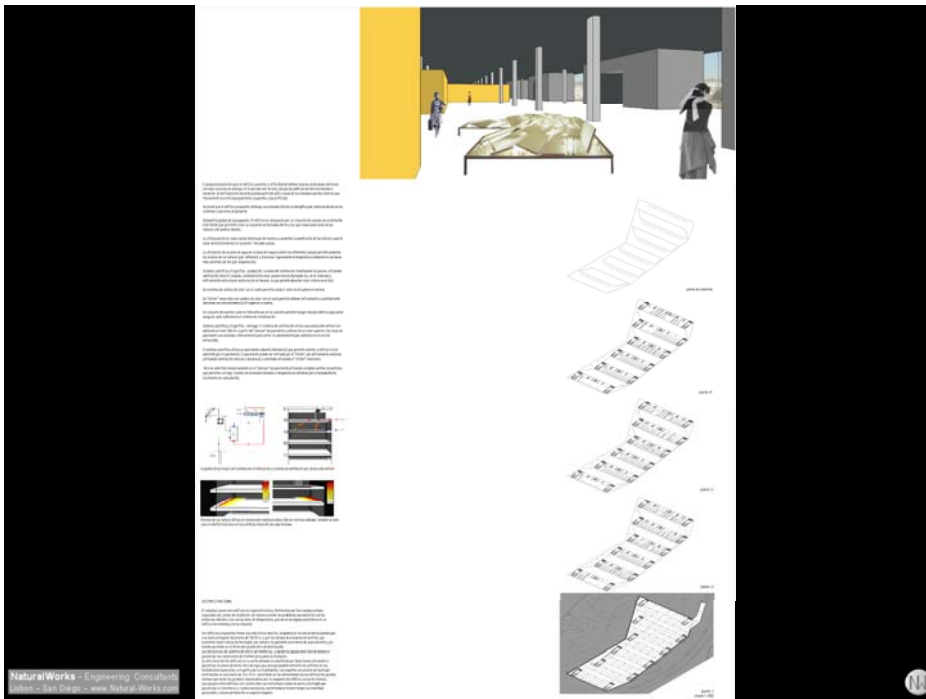
<sup>3</sup> Note that this total does not include energy spent in the circulation pumps, ventilation system fans and cooling towers.





Merida - Regional Government Headquarters  
 2000m2 Grid connected PV + Ground coupled Chiller





**Absorption**

$0.4 \times 0.8 = 0.3$

**PV/Ground Coupled**

$5.0 \times 0.1 = 0.5$

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