Thermal Performance – Low E Membranes –Evaluation and Simulation

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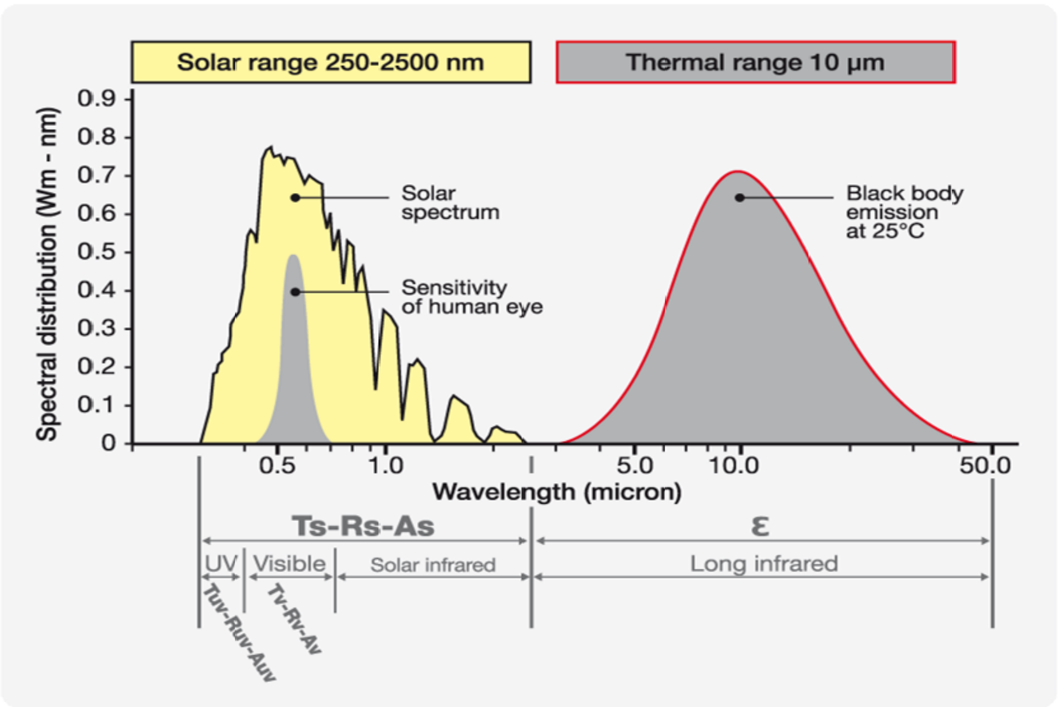
THERMAL ISSUES AND TENSILE MEMBRANE MATERIALS

By their very nature, the membranes used in the construction of lightweight structures do not have the necessary “bulk” to provide a highly efficient thermal or insulating effect. A few moderately successful methods that have been developed over the years to improve the thermal outcomes in lightweight structures, these include:

- Use of opaque materials
- Dual skinned construction

Blockout or opaque fabrics initially developed for marquee applications have been adapted for use in larger designs, but these are more effective at controlling the visible light spectrum rather than providing major improvements in emissivity.

For example the energy rejected by a blockout material is only 4 to 5% less than that of a similar weight translucent fabric. As the graph below demonstrates, the thermal range of the Solar spectrum occurs at a higher wavelength than that for visible light, therefore the control of the visible spectrum does not directly equate to large reductions in thermal gain in itself.



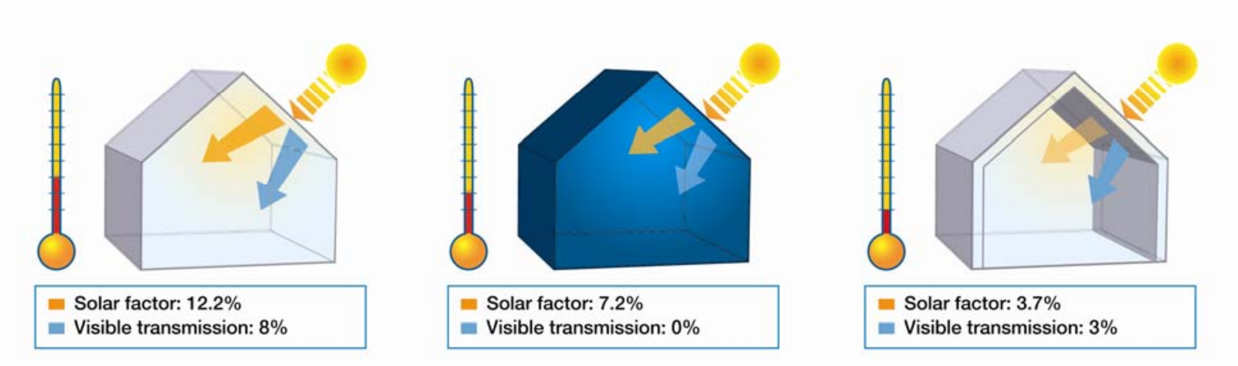
The Solar spectrum

Dual skinned membranes borrow from the 'double glazing' effect by introducing an air gap / barrier trapped between 2 layers of lightweight membrane. The gap serves as an insulator between the outer heat source and the cooler interior, reducing the rate of heat transference between the two skins.

Thermal gains in dual skinned structures are approximately 25% of that gained by a single skinned design in the same circumstances.

In the following figure the thermal gain calculations are based upon the following criteria

- Solar radiation 868 W/m^2
- Ext. Temp 25° C - Int. Temp 20° C
- Midsummer (June)
- 12.00 (Noon)
- Latitude 48 degrees 52' N. (Paris)



Thermal gain 133W/m2 Thermal gain 40W/m2

Both of these methods reduce thermal gain within a structure from radiant solar energy by the use of a screening or an insulation effect, however another method exists to reduce thermal gain and that is to lower the emissivity of the material from which a structure is designed.

EMITTANCE AND EMISSIVITY or ε

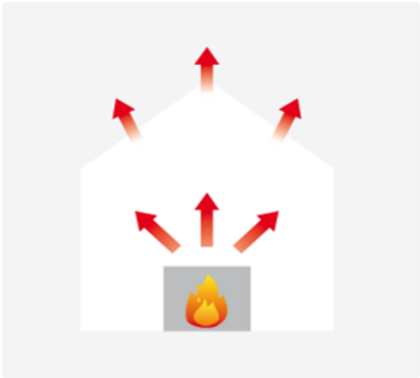
Emittance is used to describe the ability of a materials surface to absorb and then emit radiant energy. In the case of lightweight structures in Australia, the source we are most concerned with is solar energy and we are usually seeking to minimise the thermal gain effect. The more energy a material absorbs and emits, the higher the thermal gain would be for a structure fabricated in that material.

Emissivity is the ratio between a materials emittance compared to that of a 'perfect' 100% absorbing body at the same temperature - it is not measured in units. This perfect absorber of radiant energy (would have an emissivity ε of 1, conversely a material that perfectly reflected 100% of energy would have an emissivity ε of 0.

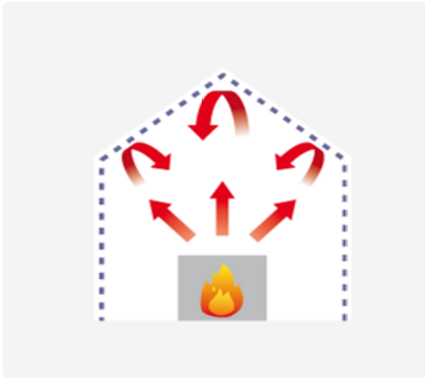
N.B. Reflection and emittance when added together always add to 1 (at a given wavelength in the spectrum).

In summary, the higher a materials emissivity the more energy is absorbed and then emitted, conversely the more reflection the lower the absorbed energy and available energy to re-emit. A material classed as Low E (low emittance or low emissivity) is therefore designed to increase the reflection rate and lower the materials emittance.

Depending upon the desired radiant energy outcome of course, Low E products can be used "in reverse" to maintain the temperature within a structure by lining the interior to reflect the energy back into the structure, as shown in the following diagrams.



Heat escape



Heat retained

Temperature Controlled Environment

Table 1 provides the emissivity values of common building materials and that of a PVC composite membrane. The results for the membrane with the Low E surface clearly show that the surface treatment successfully decreases the emissivity and therefore the thermal gain (or loss) of a structure using that fabric type.

Material Surface	Emittance / Emissivity
Precontraint 1002T2	0.90
Precontraint 1002 Low E	0.55
Precontraint 1002 Opaque Low E	0.30
Asphalt	0.90-0.98
Aluminium	0.15
Brick	0.93
Concrete	0.85-0.95
Glass (unglazed)	0.95
Steel (mild)	0.12

TAB1

LOW E COATINGS

A range of products with a specially formulated Low E coating have been produced by Ferrari for use in both the lightweight structure and Solar protection (blinds and awnings) markets. Low E coatings are microscopically thin metallic oxide layers applied to the surface of a material which are normally transparent to visible light and opaque to infrared radiation.

The principal mechanism of heat transfer is the thermal radiation of gained energy from a warm surface to a cool surface. By coating a textile with a Low-E material a significant amount of this radiant heat is reflected which lowers the total heat gain and the available energy available to emit through the material.

TEXTHERM SIMULATION

To assist Architects and air-conditioning engineers in the design of energy efficient lightweight structures, Ferrari have developed a tool called TexTherm to enable the simulation of a variety of fabric scenarios under differing conditions.

Whilst primarily used for temporary or simplistic structures, the tool would need modification for larger permanent structure use, however the principals and calculations for emissivity demonstration are accurate.

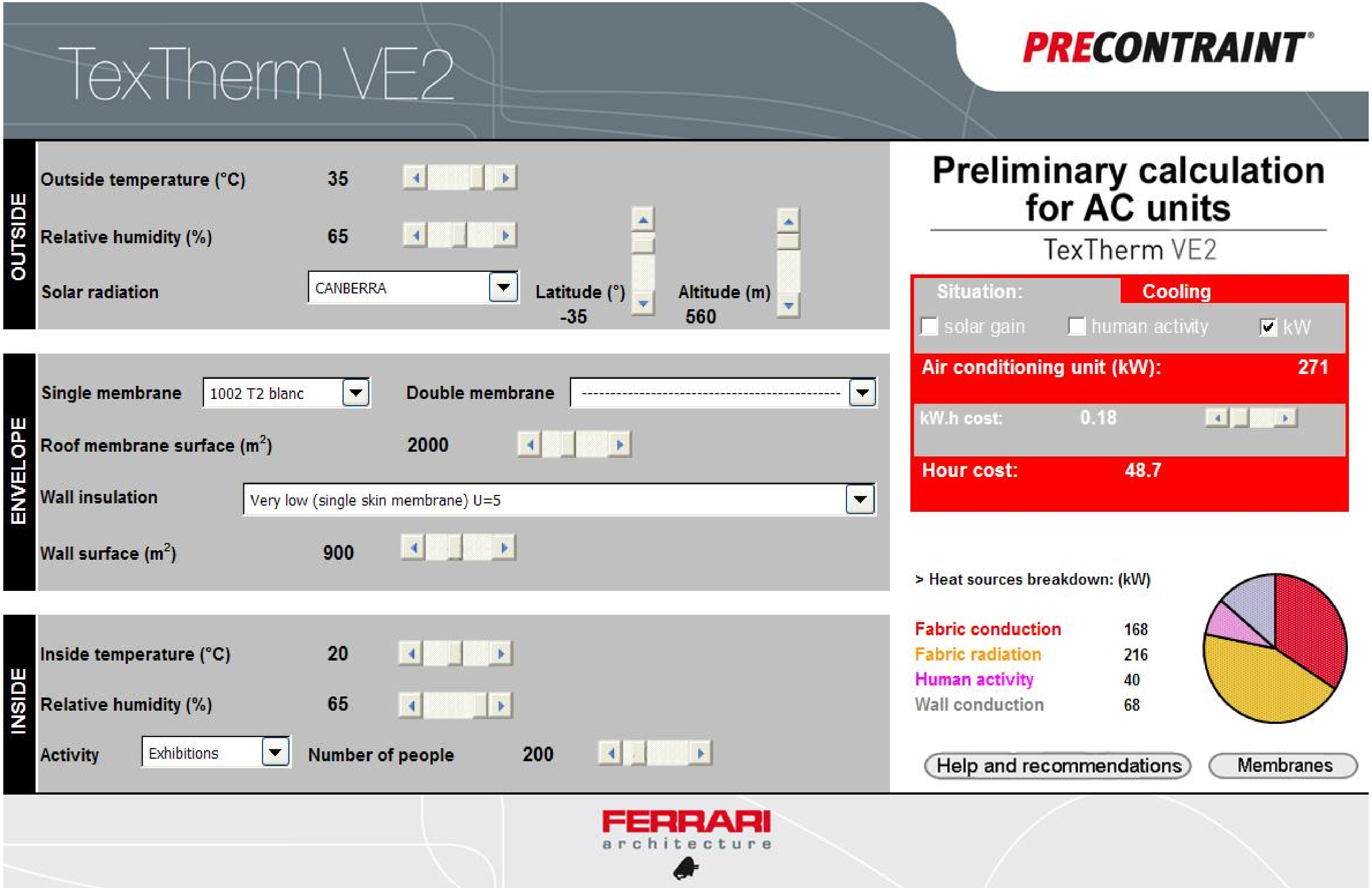
Complex shapes and structures without walls etc would require a more complex modelling program to arrive at a meaningful result.

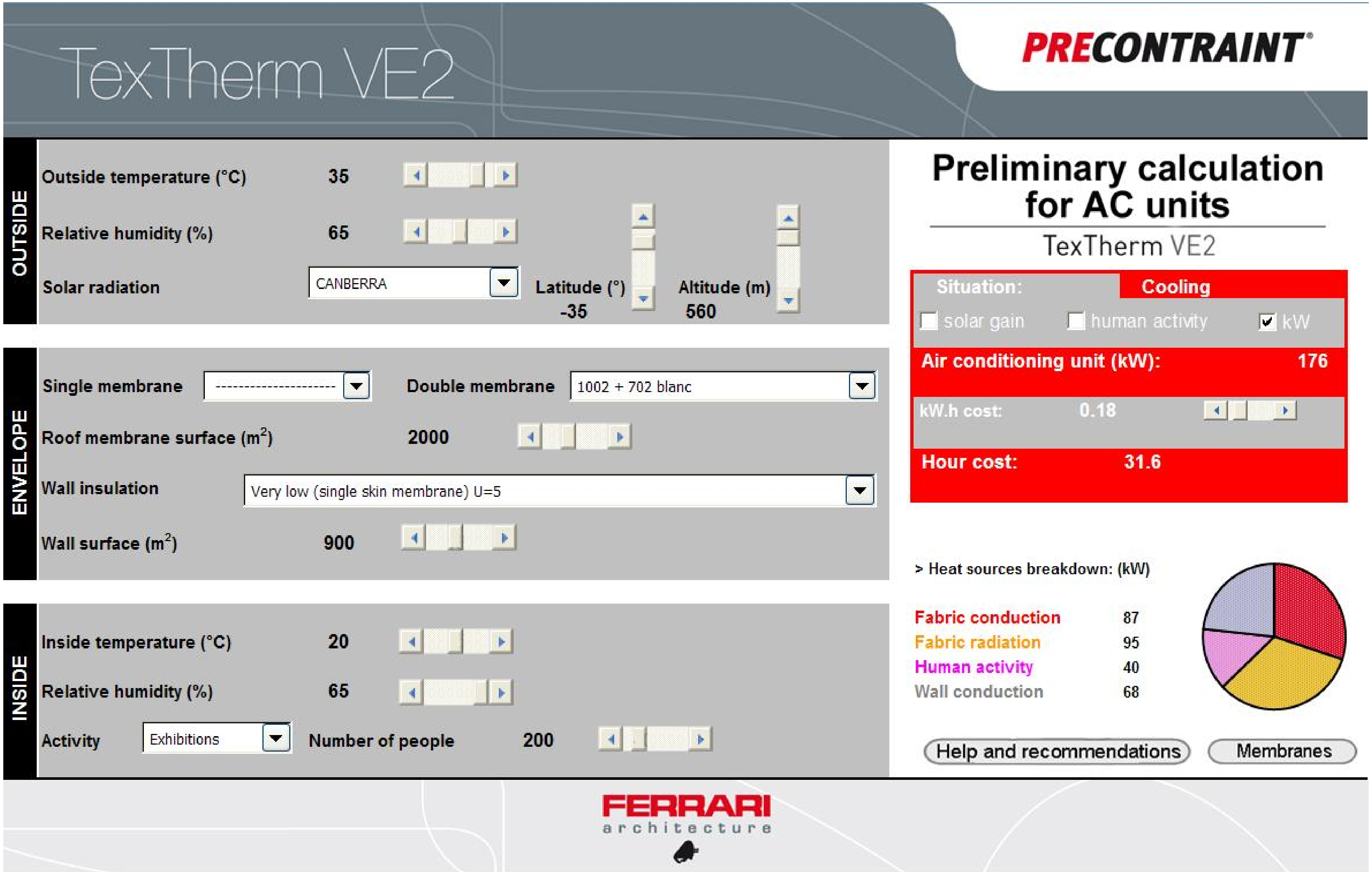
The following screenshots of the TexTherm tool show 2 differing structure types and the resultant cost to maintain a fixed temperature by air-conditioning within the structure.

The parameters used in this calculation are

External temperature:	35°C
Humidity:	65
City:	Canberra
Fabric roof surface:	2000 sqm
Wall surface:	900
Internal required temperature:	20
Internal humidity:	65
Activity:	Exhibition
Number of people:	200

In the first example the structure has a single skin membrane and in the second example a double membrane is simulated. The differing capacities of the air-conditioning units required in each scenario and the hourly costs to run them are displayed for each method.


TexTherm VE2
PRECONTRAINT
OUTSIDE
Outside temperature (°C) 35
Relative humidity (%) 65
Solar radiation CANBERRA
Latitude (°) -35
Altitude (m) 560
ENVELOPE
Single membrane 1002 T2 blanc
Double membrane
Roof membrane surface (m2) 2000
Wall insulation Very low (single skin membrane) U=5
Wall surface (m2) 900
INSIDE
Inside temperature (°C) 20
Relative humidity (%) 65
Activity Exhibitions
Number of people 200
Preliminary calculation for AC units
TexTherm VE2
Situation: Cooling
solar gain
human activity
kW
Air conditioning unit (kW): 271
kW.h cost: 0.18
Hour cost: 48.7
> Heat sources breakdown: (kW)
Fabric conduction 168
Fabric radiation 216
Human activity 40
Wall conduction 68
Help and recommendations
Membranes
FERRARI architecture


TexTherm VE2
PRECONTRAINT®
OUTSIDE
Outside temperature (°C) 35
Relative humidity (%) 65
Solar radiation CANBERRA
Latitude (°) -35
Altitude (m) 560
ENVELOPE
Single membrane --------------------
Double membrane 1002 + 702 blanc
Roof membrane surface (m²) 2000
Wall insulation Very low (single skin membrane) U=5
Wall surface (m²) 900
INSIDE
Inside temperature (°C) 20
Relative humidity (%) 65
Activity Exhibitions
Number of people 200
Preliminary calculation for AC units
TexTherm VE2
Situation: Cooling
solar gain
human activity
kW
Air conditioning unit (kW): 176
kW.h cost: 0.18
Hour cost: 31.6
> Heat sources breakdown: (kW)
Fabric conduction 87
Fabric radiation 95
Human activity 40
Wall conduction 68
Help and recommendations
Membranes
FERRARI
architecture