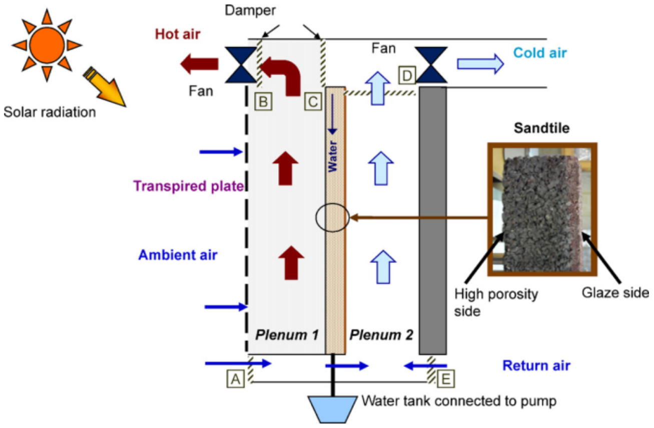
Example name: Solar space cooling facade

Template completed by:
Dr Mervyn Smyth, Uni of Ulster, m.smyth1@ulster.ac.uk

For installations

BISTS Location:
Level of BISTS integration
Rush level 2 / Reijenga level 2

~~O~~ New Build
O Refurbishment
O Other: ……………………



Type of BISTS:

Active/~~Passive/Hybrid~~

Function(s):
~~O~~ Air heating
O Water heating
O Combi-system
~~O~~ Cooling/ventilation/shading
O PV/T
O linked to another system (e.g., heat pump)
O Other: ………………………

Building element:

~~O~~ Facade
O Roof
O Other

BISTS characteristics:

The building integrated (solar thermal) cooling facade is a fan-assisted system that consists of two vertical plenums. The first plenum was made of black aluminium transpired plate and a sandtile wall, while the second plenum is formed by the sandtile wall and the building wall. The aluminium plate served as a solar collector and the sandtile wall was an evaporative pad. The reverse side of the sandtile wall that is in contact with the air in the second plenum was coated with a water-resistant layer, hence the air was cooled without adding any moisture into it.

Stage of Development:		**Responsible:**
O	Idea/Patent	
~~O~~	Prototype	University of Nottingham, Nottingham, United Kingdom
O	Demonstration	…………………………………..
O	Integral building element	…………………………………..
O	Commercially available	…………………………………..

BISTS description and context

The facade, which was also the absorber, was made from a black painted aluminium sheet 2 m in height, 1 m in width and 0.001 m thick. The porosity (ratio of hole area to total surface area) of the plate was 0.84%, with a circular hole diameter of 1.2 mm, a pitch distance of 12 mm in triangular geometry. The thermal conductivity of the sandtile material is 1.07 W m^{-1} K^{-1}, with porosity of 10.7% and density of 204 kg m−3. The water was pumped from a tank at the bottom of the plenum to the sandtile wall. The other two adjunction walls attached to both the aluminium plate and the sandtile wall were rigid polyisocyanurate foam boards with glass-fibre 70 mm in thickness and with a conductivity of 0.023 W m^{-1} K^{-1}. The dimensions of the openings at the top of the plenum were 0.23 m × 1.0 m. In addition, fans were installed at the air outlets.

System viability

The facade cooling performance under various operating conditions was investigated through experiment and theoretical analyses. It is found that inlet water temperature is the key factor affecting the cooling performance. In terms of cooling efficiency, the energy consumption to generate 1 kW of cooling that cooled the air to 293K is only 0.52 W.

Modelling and simulation tools developed/used

A simplified steady state mathematical model was developed to calculate the temperatures of the plates and the air, as well as the system efficiencies. Therefore, the temperature equations were obtained by rewriting the energy balance equations in a matrix form, and solved by the matrix inversion method. The matrix algorithm was carried out using the MATLAB programme.

BISTS Performance data

Based on:
O Estimation
~~O~~ Detailed simulation
~~O~~ Measurement/testing
O Long-term monitoring

Performance parameters

For integrated systems:
key performance indicators -

For separate collectors:
performance rating coefficients -

Other:

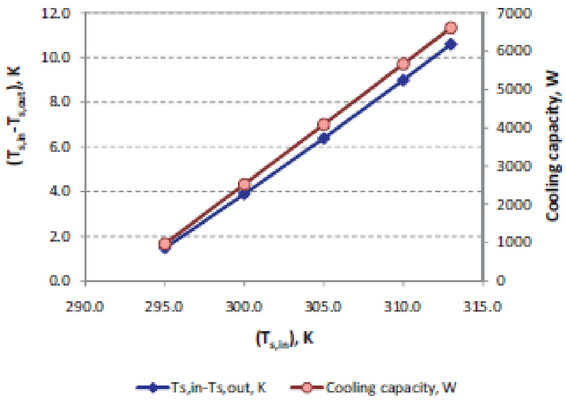


Fig. 17. Simulation results of large-scale installation with $A_p = 500\ m^2$.

System	Auxiliary energy consumption to produce 1 kWh of cooling load[a] (kWh)
Present	0.52
Vapour-compression refrigerators with different types of refrigerants	0.25–0.40
Air-conditioner with air condenser	0.22
Air-conditioner with evaporative condenser	0.16–0.39
Desiccant integrated refrigerator	0.26
Evaporative cooling with solid desiccant	1.11
Indirect evaporative cooling	0.06–0.5 0.04
Solar-assisted absorption cooling	0.19 (solar fraction = 0.75) 0.29 (solar fraction = 0.80) 1.50 (solar fraction = 0.25) 0.26 (solar fraction = 0.34) 0.10 (solar fraction = 0.74)
Hybrid solar-assisted ejector cooling/heating	0.20
Solar indirect evaporative cooling	0.50
Solar desiccant cooling	0.20 0.58 0.42 0.22

[a] Represent energy consumption from non-solar.

Additional information:

Sources and references:

HY Chana, J Zhub, S Riffat. Solar facade for space cooling. Energy and Buildings 54 (2012) 307–319