

Air-conditioning avoidance: lessons from the windcatchers of Iran

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ABSTRACT

The use of centralized air-conditioning systems in buildings with fixed windows is becoming an increasingly high-risk strategy in buildings for a number of reasons. These include fuel insecurity and price rises, the need to reduce climate change emissions from the built environment, and the need to make buildings more robust in the face of the extreme weather events that are beginning to characterize climates in a warming world. The need to be able to naturally ventilate buildings to reduce energy use in them and to make them occupiable in brown and black-outs is accepted, but in hot regions of the world is this a realistic design aim as cities become more and more dependent on high energy air-conditioning solutions? This paper outlines how lessons can be learnt from the traditional windcatchers of the Middle East

1. INTRODUCTION

Air-conditioned office buildings typically use more energy than naturally ventilated offices and consequently result in higher CO₂ emissions, in turn driving climate change, leading to the need for more air-conditioning in a vicious circle (Roaf et al., 2004). Air-conditioning, in its heartland of America, has proved to be pernicious increasers of emissions even in the domestic sector.

In America there are held to be three different kinds of air-conditioning in (Cooper, 1998):

'The custom designed systems, the plug in-appliance, and the standardized installation for the tract home – (these) illustrate the difficulties involved in integrating technical expertise into

commercial products. None of these systems fit perfectly the interests of the engineer, the company, and the aggregated groups known as the consumer.... The customer-designed system produced the most technically rational design but surprisingly afforded the user little flexibility. The plug-in appliance privileged the consumer, but its complete divorce from the building compromised its performance. The standardized installation of the tract development provided affordability and performance, but in a buildings that was dependant upon its mechanical services and alarmingly inefficient in energy consumption.'

The extent of the dependence of building users on such inefficient air-conditioning systems in thin, light buildings in American was also a conclusion drawn in another classic work on air-conditioning America, by Marsha Ackermann who, in mentioning that Lewis Mumford, at the age of 75 wrote that air-conditioning was deeply complicit in our society's authoritarian tendencies towards control, Ackermann (2002) wrote:

'The counterpart of technologically enabled control is dependency, and the history of air-conditioning provides it in full measure. Air-conditioning has made it possible to erect structures that must be evacuated when the power fails, to make buildings in which people get sick. It gulps electricity; roars, wheezes, and whines; makes urban heat islands even hotter with the exhaust of a million air-conditioned cars and thousands of sealed buildings'.

Moreover the use of air-conditioning in fixed window buildings, has been associated with increasingly flimsy envelope performance, minimalised internal mass, larger glazing areas and the elimination of external shading. These fea-

tures ensure that buildings are increasingly unable to adapt to changing climate at a time when electricity costs are becoming increasingly prohibitive to many building users.

These factors are now indicating that the time is approaching when we will all, sooner rather than later, have to re-structure our expectations and our habits to refocus our efforts and investments on what the provision of our basic needs: shelter, health, real comfort, security and survival.

We need to extricate ourselves from the market place that sells comfort and air quality as a product rather than an 'attribute or property of the building itself'. Rather than wasting time discussing and rewarding small incremental improvements in the efficiency of a dated and profligate technology we urgently need to reorganise the 'normality' of what constitute a good building, if we are to survive (Shove, 2003).

2. LESSONS FROM THE WINDCATCHERS

2.1 *An ancient and varied technology*

A key question in designing robust climate-resilient buildings for is that of whether, if at all, buildings can be designed to withstand extremely hot summer temperatures. Here we can learn an important lesson from the windcatchers of the Middle East (Roaf, 1989).

There is no one single design of windcatcher

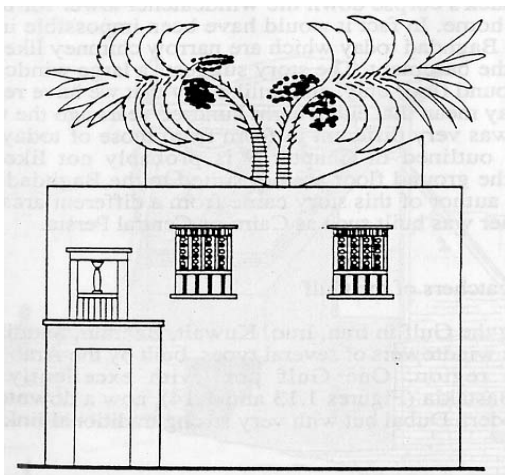


Figure 1: Windcatchers on the Pharonic house of Neb-Ammun, Egypt, 19th Dynasty, c.1300 BC, British Museum).

type but rather they are cleverly tailored to suit the local climatic conditions. On the high plains of north-eastern Iran they are nothing more than small cowl ventilators on the apex of living room domes.

In the extremely hot climates of the Gulf, where in the traditional heavy mass structures, the only viable strategy for cooling in buildings without basements is to move as much air as possible across the living areas of the house, over the skin of occupants who are thus evaporative cooled.

The windcatchers in such regions are extremely large and coupled with ventilated wall and parapet systems to maximize the cross flow of air around the house. In the extremely hot interiors of Iraq, the parapet ventilators are linked by narrow ducts to the basements rooms only, occupied on hot afternoons, to provide nominal ventilation as the air entering the spaces from the roof may well be at temperatures in the mid-40s C. In the cooler desert city of Cairo windcatchers have been used for millennia as large roof ventilators passing air down through the high living halls in conjunction with cupolas at the apices of domes above the halls called in Arabic Qa'a.

2.2 *A Litmus Paper Technology*

Traditional windcatchers are used in four ways:

1. To provide basic ventilation, as in Baghdad.
2. To provide convective cooling for people where they supply indoor temperatures between 25-35^oC.
3. To provide evaporative cooling of people at temperatures above 35^oC.
4. To cool the structure of buildings down by either coupling the internal air temperatures to those of the night sky or with the earth in basements and underground tunnels and streams, typically in regions too hot for internal convective cooling to be enough during the day.

By simply looking at the form of local indigenous windcatchers, in relation to the spaces served, observers can get an idea of what the local summer climate is in a region from the form and size of the tower.

2.3 *Earth, water and mountain coupled towers*

As the climate warms over the coming decades



Figure 2: Great windcatcher in Bahrain where the hot humid climate requires that maximum air movement over the skin is achieved to stimulate evaporative cooling for summer comfort.

some of the traditional windcatchers will cease to provide adequate passive cooling and their performance may have to be enhanced if buildings are to remain comfortable without mechanical cooling, and in periods when mechanical cooling is not an option because electricity supplies fail.

In such cases the performance of a windcatcher can be significantly enhanced by coupling it to either the earth, air or water heat sinks. Perhaps the most elegant example of such a traditional system is that of the Bagh-e Khan in Yazd, Iran where the basement living room occupied on summer afternoons is linked by a tunnel some 50m long to the wind-catcher tower that passes over an underground water canal (qanat) that runs from the mountain aquifer some 20 miles to the south east at some 500. higher to the city of Yazd on the plains below.

The original tower drew fresh cool air from the tower alone by due to the poor draw of the system the owner installed a small fan, such as could be powered by a 70 watt photovoltaic panel in the mouth of the tunnel. This system supplied air at c. 25°C to the basement when the external air was at over 40°C. Similar links to underground qanat tunnels were traditionally built in many of the basements of houses



Figure 3: Pavillion of the Bagh-e Khan served by the windcatcher with chilled mountain air and water via a qanat canal.

throughout the city of Yazd.

There is enormous potential for the use of such sky, water and earth coupled systems to significantly reduce the temperatures in the summer living areas of buildings in hot climates. In the Gulf States, a region with one of the most challenging to design for in the world, passive cooling systems were barely adequate to maintain comfort in the summer months, many of the inhabitants of the surrounding states were migrating nomads who would leave the area in the summer months for cooler mountain pastures. New cities such as Kuwait city have emerged only in the last 50 years and are now composed largely of large buildings, of light weight construction, and increasingly of glass, that are simply not inhabitable without air-conditioning systems. Studies done indicate that in less than half an hour such structure would have soaring internal temperatures over 50°C in the summer.

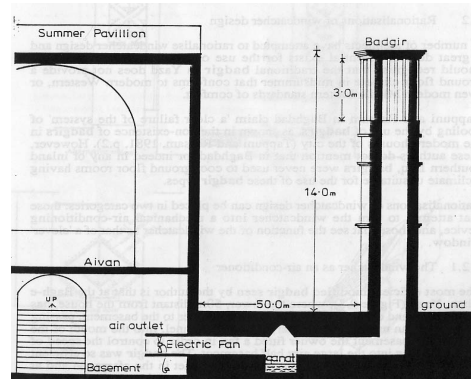


Figure 4: Section through the pavilion, tower and qanat at the Bagh-e Khan, Yazd.



Figure 5: The emerging cities of the Gulf region are composed of cities such as Kuwait that are completely dependant for indoor comfort on air-conditioning systems. Till now only 20 story towers were allowed but this year permission is given for a 100 story glass tower.

The only effective passive method of reducing indoor air temperatures without the use of mechanical systems in this area of high humidity is to couple the air temperatures with those of the ground or the sea. In mid summer when maximum air temperatures can rise as high at 53°C the stable earth temperature at 6-9m below ground is 28°C and even the sea temperature in the dead end Gulf waters is at around 16°C in January and in August 33°C .

Using methods of earth coupled cooling and heating systems to ground source heat and coolth pumps it would be possible significantly reduce internal temperatures, in well constructed, heavy, passive buildings to below 35°C , temperatures at which convective cooling of people can still operate effectively and com-

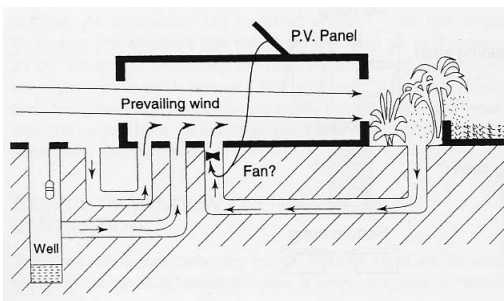


Figure 5: Simple systems that are able to incorporate stable core temperatures of the ground or water bodies, or even mountains far away may supply a reliable source of low temperatures in the future. If operated using renewable energy powered systems with good micro-climatic design and significant passive engines such as wind towers, stack systems or cross ventilation flows they may be able to ameliorate even extremely hot conditions for adapted local populations.

fort be maintained in periods of high heat and high humidity.

At a time when brown-outs and black-outs are predicted in the region because of very high levels of population increase, the rock bottom price of electricity, at \$0.1 US, and the increasing summer temperatures, people will not be able to stay in many buildings there if the electricity fails during the day in particular.

If people in cities such as Kuwait are going to survive until the middle of this century with their lifestyles in tack then there will no choice but to reduce the dependency of buildings on fossil fuel generated electricity and incorporate innovative, heat sink-coupled systems into simpler more passive buildings that are able to maintain indoor comfort temperatures even when the grid power supply fails.

3. AN ESSENTIAL PALETTE OF ADAPTIVE 21^{ST} PASSIVE COOLING SYSTEMS

The key to the survival of many cities in more extreme climates must be to abandon the monoculture of air-conditioning as a solution to designing buildings for such regions in the future. The twin challenges of building in a warming climate and world of increasingly expensive fossil fuels provide two incontrovertible reasons to abandon such buildings immediately.

All buildings from now on should be designed to enable inhabitants to remain in them in extremely hot (or cold) weather even when

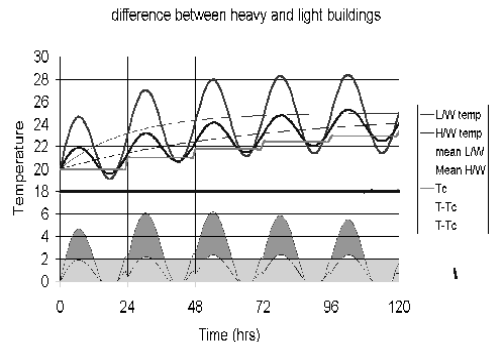


Figure 6: By increasing the Passive Adaptive Opportunities in heavy-weight buildings that can be drawn on to increase the difference between indoor and outdoor temperatures, one not only lowers running costs but also increases the temperature range in which the buildings can be comfortably occupied without air-conditioning (Source: Fergus Nicol).

the lights go out. In order to do this it is essential to re-learn from the vernacular master-builders lessons of how to provide a range of adaptive building features that may extend the range of occupiable temperatures within them over a year.

An essential ingredient in capitalizing on such adaptive opportunities is to ensure that an adequate degree of thermal mass is incorporated into the building (Meir and Roaf, 2002). These should operate with a minimum of at least a 12 hour time lag so that night coolth may be used for day-time cooling indoors. Monthly heating time lags or inter-seasonal or inter-regional coolth storage is possible. This was evidenced by the mountain coupled systems use in the basements of Yazd in conjunction with wind-catcher systems.

Traditionally, the skill of the windcatcher designer was passed on from Ostad to Ostad (master builder) but such men no longer exist in the Middle East. But the building still do and their wisdom, encapsulated in the structures and systems they created, should now be studied seriously by all students of building design in order that their ingenuity is passed on (Meir and Roaf, 2005). What we can now do is to use the advanced tools and methods to hand to analyse, interpret, refine and apply the traditional palette of systems to modern buildings and their boundary conditions through studies in universities (Meir et al., 2004) and in practice. One advantage of such tools is that they should be able to prevent us from applying technologies where they are climatically inappropriate simply because we associate them the traditions of that region (Roaf, 1990).

4. CONCLUSIONS

Trans-regional, climate sensitive, technologies such as the windcatchers of the Middle East can provide us with the inspiration for new and innovative approaches to the design of resilient, adaptive, passive buildings for hot, and warming, climates, as well as give us an indication of our ability to survive in buildings in such regions without air-conditioning.

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