# 739: The Traditional Technology Trap (2): More lessons from the Windcatchers of Yazd

**Susan Roaf** [1]

*Professor of Architectural Engineering,*
*Heriot Watt University, s.roaf@sbe.hw.ac.uk*[1]

**Abstract**

As scientists we tend to view technology as a scientific system but in fact the success of a particular technology at a particular time may be rest less on its efficient performance and more about its 'social' relevance and impact. We now need to identify sustainable design investments for a very uncertain future of expanding populations, scarcer resources and climate change. The great windcatchers of Yazd are a zero carbon cooling technology, but because the high towers of Yazd grew too large during a period of economic boom and soaring social hubris these structures may survive less well than if they had been more modest in their design. This paper explains why the high towers of Yazd were built and reminds us that the sustainability stool has three legs, and if you loose one, the stool falls.

Keywords: natural ventilation, human comfort, sustainable solutions

## 1. Introduction

Sustainability, we are told, is a stool with three legs: economy, society and environment. But we are scientists who, by habit and inclination, reduce subjects to one or a few scientific variables to enable us to understand better the complex interactions that, for example, make buildings work as they do. Reductionism can, however, lead us missing the point about why things appear to be as they are in the reality of the complex ecosystems we inhabit. The example of the windcatchers of Yazd will, I hope, demonstrate that technical performance plays but a part in their design.

In an article 'The Traditional Technology Trap [(1)], based on field work for a PhD on the wind-catchers of Yazd, in the 1970s[(2)] , I reported that researchers and designers had traditionally made the mistake of thinking that the windcatchers of the world all work in the same way. Researchers believed, without questioning, the findings of those who had published on the subject before them since 1950, following emerging stereotypical lines of thought that led many away from the truth. Forms and functions of windcatchers in reality vary enormously with micro, meso and macro-climate, geomorphology and the comfort expectations and habits of locally adapted populations.

The consequence of misunderstanding why and how windcatchers are designed led, the original article argued, to the building of inappropriate 'pseudo-traditional' building solutions that in turn caused, in some cases, a wider disillusionment with the 'low tech' or modern vernacular design solutions. A battle is raging between those who believe that in the 21st century our salvation lies with traditional 'low tech' or 'high tech' solutions [(3)]. There was already a genuine concern by the early 1990s that a shift towards the high tech, air-conditioned buildings for instance, would significantly increase the greenhouse gas emissions from the built environment further driving climate change and reducing the quality of the building fabric in the process. This has proved to be true[(4)]. Since then research has demonstrated that populations in different regions, climates and cultures do occupy a unique range of comfortable temperatures[(5,6)] in their homes and work places based on the daily thermal experiences that shape, and are shaped in turn by, their own choices[(7)].

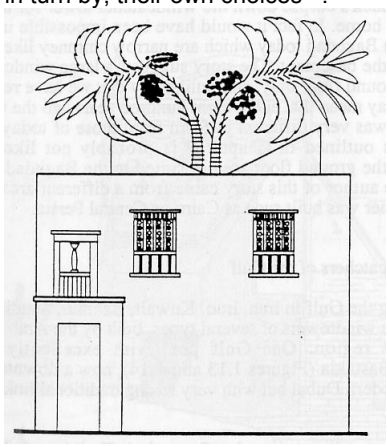

*Figure 1. Windcatchers on the Pharonic house of Neb-Ammun, from A wall painting on the wall of his tomb (19th Dynasty, c.1300 B.C., British Museum)*

*Figure 2. Elaborate details combine elegance with aerodynamic performance*

The concern with climate change is that as the world warms then traditional thermal thresholds that guide the safe thermal experiences of the individual's diurnal thermal experience in the traditional homes of 95% of the worlds population will be breached. Homes will become too hot to occupy[8].

The dream of the 20th century was that air-conditioning would solve this problem and bring high levels to comfort to all, as systems became available to all[9] but this dream has been shattered by the soaring costs of fossil fuels and delivered energy that makes it increasingly likely that only the very rich will in future be able to afford mechanical cooling, unless renewable energy systems can be made widely available in the very near future[10] .

There is a hope that with intelligence people will learn to adapt to the shifting temperature zones of a warming world using minimum carbon strategies[11] sequentially adopting more effective passive cooling systems as temperatures rise. Research should inform the modification of our local vernacular building types[12] and the necessary upgrading of the passive systems to make the buildings sufficiently resilient to the increasing extreme weather that will be experienced.

Such adaptations appears to be sensible and appropriate but any technical evolution may well lead to unintended consequences in the form of economic or social impacts that could have been better anticipated and minimized by policy interventions at an early stage.

No technical solution in the real world exists in isolation of its economic and social consequences and at a period when there is a pressing need for forced and effective change to combat rapid climate change and soaring prices of fossil fuels, we had better try to anticipate those consequences, or possibly be damned by them. The windcatchers of Yazd provide an historic example of the fundamental inter-connectedness that exists between technical, social, economic and political decisions in reality.

## 2. Description of the case study

Yazd is known in Iran as the 'Shah-e-Badgirha', the City of Windcatchers. It has the tallest and most beautiful of all the great windtowers of the world and they adorn the homes, caravanserai, baths, water cisterns and mosques of most of the settlements of the central plateau of Iran and many others beside it. I began my field work on the 'badgirs', or windcatchers, of Yazd in 1976. My original article on the Traditional Technology trap (1) outlined how each village has a unique assemblage of its own towers with a unique range of tower heights, dimensions, orientation and decorations resulting from local geomorphology, micro-climate, local building skills and traditions and the social, economic and historical evolution of a particular settlement[1].

I had always presumed that the city of Yazd had the tallest towers in the world because the climate there was perfect for providing comfortable summer cooling with the brisk winds they channelled into the rooms at the right temperatures for summer cooling. The towers were taller to catch the less dusty, cooler, higher air streams and the higher they were the faster the winds that were channelled through the summer rooms. This must, to some extent have been true because the Yazdi would surely not have incorporated towers that were leading to significantly less comfortable conditions indoors in a climate already too hot in summer.

The windcatcher systems of Yazd are, at best, highly complex ventilation engines drawing pressurised air up or down the tower, through underground cool basement rooms, planted courtyard with trees and pools of water and through the high summer 'talar' rooms on the raised ground floor facing west or north west away from the sun. The more complex the pathways through the building structure the stronger the pressure needed to keep a good air flow through them. After many years working on the traditional buildings of the region I noticed that it was only during the Islamic period – after c. 1000AD that houses began to be built with deep basement rooms where in Yazd the summer afternoon siesta is still enjoyed. We do not have the literature to tell if these rooms were always used so but certainly by the 15th C. Timurid period there was wide use of basements, and semi-basements in large merchant homes of Yazd.

By the early 19th century some of the wealth of the caravan traders and the silk manufacturers was put into enormous house complexes built by some of the greatest master builders in the field of passive cooling of buildings in the history of the world.

The Haram, or the women's quarters, of the governor's garden palace at the Bagh-e Dowlatabad at that time had three wind towers

linked via the basement rooms in an extremely effective passive cooling system and the 4m by 4m main tower has increased in size to effectively pump more air through the two basements to be expelled via the twin satellite towers over two ornate living rooms. By 1800 AD complex cooling systems were fed by towers that were expanding in cross-sectional areas, but not height. But all that was to change.

*Fig 3. The tallest Yazdi windcatcher, 32m high on the Khan's summer pavilion at the Bagh-e-Dowlatabad*

In 1272 Marco Polo visited Yazd and wrote[13]:
"*Yasdi is also properly in Persia; it is a good and noble city, and has a great amount of trade. They weave there quantities of a certain silk tissue known as YASDI, which merchants carry into many quarters to dispose of*".

Polo describes the windcatchers of Hormos in some detail but does not mention them in Yazd.

In 1474 the Venetian Josafa Barbaro[14] described Yazd as follows:
"*From thense, following on or, waie we came to Jex, a towne of artificers, as makers of sylkes, fustians, chamlettes and other like. This towne is walled, of v miles in circuite, With very great suburbs."*

By the seventeenth century the travellers still did not mention the badgirs. Tavernier, who wrote with interest about the wind chimneys of Lar and Ormus[15],described Yazd in some detail, having spent three days there, in 1678:
"*It is a great Town (YEZD) in the middle of the Sands, that extend themselves for two Leagues around it: .. . Between the Town and the Sands there is a little good soil, which produces excellent Fruits. There are three Inns i'th' City, and several BAZARS or Market places cover'd and vaulted, which are full of Merchants and Workmens Warehouses*".

In 1826 Pottinger wrote[16]:
"*Yezd is a very large and populous city, situated on the edge of a sandy desert, contiguous to a range of mountains running east and west. The city has a mean appearance, and has once had a wall, part of which still remains."*

No mention of its badgirs. In around 1870 there appears to be a turning point in the history of the badger in Yazd. General Goldsmid, writing 10 years after his first visit in 1867[17], tells of three important events that had occurred in the decade of the 1860s. There was a great famine, a new bazaar was built, and badgirs appear as a dominant feature of the skyscape of Yazd:
"*Towards the end of 1870 I marched down the road to Bushire from Shiraz . . . At every halting place crowds of famished half-naked men and boys (the women and children were nearly all dead) thronged around our camp, too weak to beg…….Yazd, Isfahan, and Khurasan were …….diminished by a third at least . ..The city (Yazd) is large and comparatively populous: but it has few buildings save one mosque worthy of notice; and it is choked with ruins within and around. The new bazar looked handsome enough of its kind; but the older bazars are very dark, ruined and dirty."*
But on his approach to Yazd from the village Girdfiramuz some six miles from Yazd[18] he wrote:
"*At this point the minarets and badgirs of Yazd were visible*".
An astounding fact is the lateness of the earliest eye-witness account by Europeans of the badgirs of the city. Goldsmid, the first wrote on his visit in 1871 after which every traveller mentions the towers as the first things seen on approaching the city as they had then become highly visible. The civil war in the region in the first half of the century and the famine had reputedly reduced the population of Yazd from 100,000 at the beginning of the century to 40,000 in the decade of 1860-70 [19]. Then a new prosperity led to the building of the new bazaar on which the first high badgirs rose above the roofs of the city.

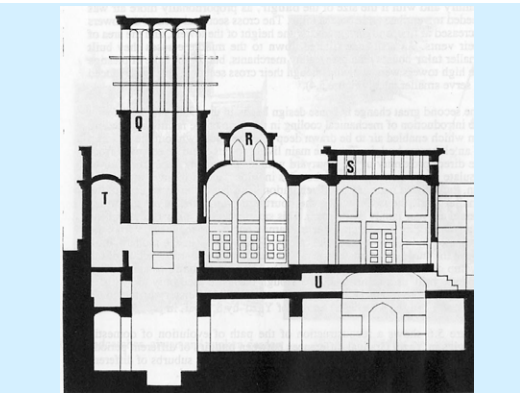


*Figure 4. Complex building sections enhance performance: Q = Badgir; T = Buffer room; R = Cupola; S = double roof; U = ceiling void*

The reason for the new prosperity in the city was opium. In Abbott's reported to the Foreign Office in 1853[20]:
"*The Opium is of a quality much esteemed in Persia; and though its production is at present limited by demand, I believe that it might be obtained within a moderate period to almost any amount for which a market could be found…. The amount of it obtained yearly varies considerably, and seems to depend on a very uncertain demand; it may have been in 1849 - about 1,300 mens shaheh (equal to 17,000lbs) which was stated to be less than usual; and a great deal more might be produced in a short time on order. Occasionally an active demand occurs for it for Meshed and Afghanistan (probably for China through Bokhara and other parts) for which market it is said to be well suited….. The Guebers are the principal cultivators of the poppy, which is raised in about 21 villages around*".

A number of authors mention the opium trade and the best account of it is by Stack in 1882[21]:
"*The grand staple of Yazd is opium. All the fields around the city, while I was there, were white with poppy, and the time for gathering the opium had just begun . . . The opium trade of Persia dates from the Chinese war…..In the security afforded by the British occupation of Hong Kong, Persian opium began to find its way to China. The prohibitive duties in the Indian ports were a great obstacle and for a long time more opium went to Constantinople than to Hong Kong. The route via Ceylon was struck out by certain merchants of Yazd, and now in these latter days opium is shipped direct for China from Bandar-Abbas by steamers of the Peihi Company. Last years export was 6000 peicul or boxes; this years export(1881) is expected to reach 8000 boxes. In 1871 the export was 4000 boxes. Thus the trade has doubled in ten years, and perhaps is increasing now faster than ever before….. Still if the shah could bring himself to spend some of his hoarded money on improving communications with the sea, it seems quite possible that the rivalry of Persian opium might be sensibly felt in India……Next to opium, silk is a notable product of the Yazd district, but the industry has much declined of late. There were 1800 silk-houses here a few years ago, there are scarce 150 now."*

Opium had replaced silk as the principal product of Yazd after the Anglo-Chinese wars of the 1850s, when China was opened up by the British to international trade. This led to a boom in the economy of Yazd, that produced much of that opium, leading in turn to the building of the new bazaars and houses on which high badgirs were built. The new economic upsurge in Yazd, due to an opium boom went hand in hand with a new trend in badgir height, type and elaboration in the later quarter of the nineteenth century. In a city of narrow streets flanked by high mud plastered walls the only places to show off wealth was in the ornate front doors and knockers onto the streets and the height and magnificence of the badgirs of the Yazdi's home.

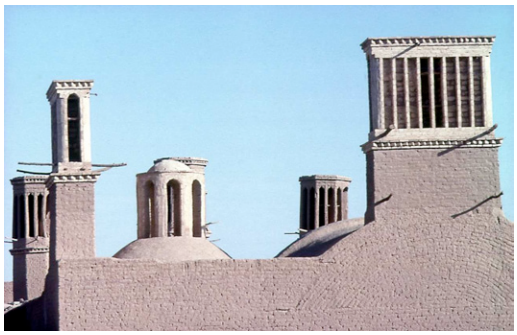

*Fig 5. Domestic badgirs on the village of Nausratabad.*

## Conclusions

Buildings technologies fluctuate in their prominence and popularity over time and by region. The zenith of the world history of the windcatcher came in late 18th century Yazd where the greatest of all windtowers were built, paid for by the British peddling opium into the Chinese population as a means of subjugating China and expanding the influence and reach of the British Empire. A consequence of the rise of the opium trade in Yazd, was the increasing in the wealth of Yazdi opium merchants who built the high badgirs. The silk industry re-located to Balkh in northern Afghanistan, the new silk capital of Central Asia where, in a related flowering of another technology, some of the greatest of the world's ice-houses were built. But that's another story.

The badgirs of Yazd demonstrate the complex inter-connections between society, economy and technology in a world in which physics dictates that what rises must also fall. A technology that is appropriate to one age may soon fall out of favour. Look at the phenomenal rise of other types of high towers in so many cities around the world today, and ask yourself what will become of them in an age when they cost too much to run and the oil based wealth of their owners dries up?

The design of any popular technology may be less about optimal performance and more about its 'social' impact. We need now to identify sustainable investments for a very uncertain future of expanding populations, scarcer resources and climate change. The great windcatchers of Yazd are a zero carbon cooling technology, but because the high towers of Yazd grew too large many will introduce too much hot summer air into the homes and basements of Yazd in a warmer world, leading to the need to increase air-conditioning use in them, or abandon them. Small windtowers, such as were used in earlier centuries before the 'Little Ice Age' of the 17th and 18th centuries and are still effective in hotter countries today will be less vulnerable in the warming climate of Yazd. The

Traditional Technology Trap (1) reminded us not to follow the stereotypical thinking of 'conventional wisdom' but to re-think each design decision clearly for ourselves and (2) reminds us that the sustainability stool has three legs, and if you loose one, the stool falls.

## References


1) Roaf, S. (1990). The traditional technology trap, *Trialog*, vol. 25, pp. 26-33.
2) Roaf, S. (1989). The Windcatchers of Yazd, Phd, Oxford Polytechnic.
3) Meir, I and S. Roaf (2003). Between Scylla and Charibdis: In search of the sustainable design paradigm between Vernacular and Hi-Tech, Procs. PLEA Conference, Santiago, Chile.
4) Roaf, S. (1992). The problems of air-conditioned buildings, *Proceedings of the World Renewable Energy Council conference*, Reading.
5) For the five different climate zones of Pakistan this was clearly demonstrated in: Nicol, F., Jamy, G.N., Sykes, O., Humphreys, M., Roaf, S. and Hancock, M. (1994). *A survey of thermal comfort in Pakistan toward new indoor temperature standards,* School of Architecture, Oxford Brookes University. ISBN 189940400 7

6) For Europe a wide range of comfort temperatures was reported on in: Nicol, F. and McCartney, K. (2001) *Final report (Public) Smart Controls and Thermal Comfort* (SCATs) (also subsidiary reports to Tasks 2 and 3 and contributions to reports to Tasks 1, 6 and 7) Report to the European Commission of the Smart Controls and Thermal Comfort project (Contract JOE3-CT97-0066) Oxford Brookes University.

7) Nicol, J.F. and Roaf, S. (2007). Adaptive thermal comfort and passive architecture, in Santamouris, M. (ed) *Advances in Passive Cooling,* London, Earthscan ISBN 1844072630/978-1-84407-263-7

8) Roaf, S. (1990). The significance of thermal thresholds in the performance of some traditional technologies*, Proceedings of the North Sun Conference*, Reading, Pergamon.
9) Markham, S.F. (1944). *Climate and the energy of nations*, Oxford University Press.
10) Roaf, S., D. Crichton and F. Nicol (2005). *Adapting Buildings and Cities for Climate Change*, Architectural Press. ISBN 075065911 4
11) Haves, P., Roaf, S. and J. Orr (1998). Climate Change and Passive Cooling in Europe*, Proceedings of PLEA Conference*, Lisbon**,** May, James and James, Science.
12) Meir, S. and S. Roaf (2005). The future of the vernacular: Towards new methodologies for the understanding and optimisation of the performance of vernacular buildings, in L.Asquith and M. Vellinga (Eds.), *Vernacular Architecture in the Twenty-First Century: Theory, Education and Practice,* Spon.
13) Yule, Sir Henry (1921). *The book of Ser Marco Polo*, John Murray, London, Book I, p. 88.
14) Barbaro, Josafa (1873). *The travels of Josafa Barbaro*, The Hakluyt Society,Lon., p. 73.
15) Tavernier, J.B. (1678). *The Six Voyages of John Baptiste Tavernier,* London BookV, p. 254.
16) Pottinger, Lieut. Henry (1816). "Travels in Beloochistan and Sinde, (travelled in 1810) with an Appendix of travels in Eastern Persia by Captain Christie, p. 421 and 422.
17) Goldsmid, Maj. Gen. Sir Fred. (1867). Notes on Eastern Persia, *Journal of the Royal Geographical Society,* vol. 37, London, pp. 274-285. Using extracts from the Diary of Col.Euan Smith.1867, p. 277.
18) Goldsmid, Maj. Gen. Sir Fred. (1876). *A journey through Baluchistan and Southern Persia*, London, p 172.
19) Curzon, George Nathaniel (1966). *Persia and the Persian question*, 2 vols., 2nd Impression, London, Frank Cass and Co. Ltd. 1st impression published in 1882 by Longmans, London, p.240.
20) Abbott, K.E. (1853). Notes on various cities and countries of south Persia, 1849 and 1850, Foreign Office Miscellanea, 251/42/9059, Public Record Office, London.
21) Stack, E.(1882). *Six months in Persia*, 2 vols., London, p.263-265.


*Figure 6. Windcatchers evolved over time*.