A Case Study of Masdar City: Feasibility of adapting Masdar city to Yazd, Iran

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PROJECT DATA

Masdar city

Abu Dhabi Emirate

United Arab Emirates

Head:	Mubadala Development Company
Client:	Masdar-Abu Dhabi Future Energy Company
Designed by:	“Foster + Partners” Architectural Firm
	Mott MacDonald
Additional Consultants:	Gustfson Porter
	Ernest&Young
	Gillespies
	Trannsolar
	Flack + Kurtz
	Systematica
Quantity Surveyor:	Cyril Sweet Limited
M+E Engineer:	PHA Consult
	W.S.P
	Transsolar
	E.T.A
Occupancy:	Mixed-use
Square Footage:	2.3 Square mile
Estimated cost:	Over 22 billion $
Start Date:	2006
Estimated completion date:	2016

Abstract:

This case study will focus on Masdar City, a warm and humid, net-zero city project located in the United Arab Emirates (UAE).The project is distinguished by the fact that the thermal response relies on the outdoor climate and the use of mechanical HVAC systems has been minimized. This essay begins by introducing the city clients and manufactures. It then explains the unique sustainable and passive features of the design, how it mitigate the extreme climate conditions and creates a thermal comfort for the occupants of this city. In the next part, a comparison of climate data between Masdar and Yazd (a hot- arid city in Iran) has been made in order to see the feasibility of adapting Masdar city to Yazd. This case study shows that with using the vernacular architectural principals of Yazd, the passive design features can be adapted to Yazd as well; thus, making the city less dependent on fossil fuels.

Client:

In the year 2006, Masdar Corporation, a secondary of a government-owned company named the Mubadala Development, was launched under the leadership and guidance of Abu Dhabi Economic Vision 2030. Masdar initiative is one of the most profitable companies in the Emirate and a booster for the Abu Dhabi's knowledge-based economic sectors (Masdar Corporation, 2012). The policy of Masdar, which contains both theoretical and practical aspects of a renewable energy approach, is to achieve technology and investments from private and public partnerships, which will finally lead to a triumph in the clean energy industry (Masdar Corperation, 2014).

Masdar Corporate Headquarters, which is located in Masdar City, Abu Dhabi, and UAE is founded around three business units and an independent, research-driven graduate university. The universal approach and the focus dedicated to each key component of the value chain keep Masdar a pioneer in the global clean energy industry and commercially viable technologies and systems. Masdar is constructed with the broad scope needed to meet the most pressing sustainability challenges of tomorrow (Masdar Corporation, 2012).

An overview of Masdar City. It is being built by the Abu Dhabi Future Energy company, a subsidiary of Mubadala Development, with the majority of seed capital provided by the government of Abu Dhabi.
Image courtesy of Dr. Khosrow Bozorgi

Masdar's Awards:

Since the establishment in 2006, Masdar has been recognized by a wide number of industry awards for its buildings, projects and innovation.

- 2007 - World Clean Energy Award - Transatlantic21 Association
- 2007 - "Sustainable Region/ City of the Year" at Euro money and Ernst & Young's Global Renewable Energy Awards.
- 2010 - Middle East Renewable Energy Deal of the Year (Shams 1) - Project Finance Magazine
- 2011 - Best Renewable Energy Project Developer in Middle East - World Finance Magazine
- 2012 - Leadership for New Energy Award - Energy Intelligence and International Herald Tribune
- 2012 - Energy Company of the Year - Gulf Business Industry Awards
- 2012 - Project Finance Sustainability Deal of the Year for Europe, Middle East and Africa (Shams 1) - EMEA Finance Magazine
- 2012 - Project of the Year (Shams 1) - Emirates Solar Industry Association
- 2012 - Sustainable Mobility Management Award - Dubai Award for Sustainable Transport
- 2012 - Best Contribution to the Reputation of the Procurement Profession - CIPS Middle East
- 2013 - Emirates Energy Award- Large Energy Project Award (Shams 1) - Dubai Supreme Council of Energy
- 2013 - Outstanding Performance in Supply Chains - IIAPS
- 2013 - Outstanding Performance in Ethical or Sustainable Supply Chains - IIAPS
- 2013 - Global Wind Deal of the Year 2013 (London Array) - Project Finance International
- 2013 - Global Renewable Deal of the Year (London Array) - Project Finance International
- 2014 - Gold Award for Excellence in Procurement and Supply Chain Practices - CIPS

- 2015 - MENASOL Awards 2015: CSP Developer of the Year (Shams 1) - CSP Today / PV Insider

Designer:

1-"Foster +Partners" Architectural Firm

Founded in 1967, the firm has pioneered a sustainable design approach, from master plans to furniture. The important variables in their design process require using both latest advances in building technology as well as techniques drawn from vernacular architecture, location and culture (Foster + Partners, n.d.).

Working together; using an integrated and creative approach from conception to completion; joining the skills, enthusiasm and knowledge of united design teams, clients and communities is the key to formulate inspirational environments and cohesive, sustainable design solutions in the projects as they believe (Foster + Partners, n.d.).

Corporate, Social and Environmental Responsibility (CSER):

The Corporate and Environmental Social Responsibility (CSER), which is taking responsibility for the company's effects on environmental and social well-being, is one of the top priorities for a company that claims to be one of the promoters of sustainable design needs in their work. The CSER program is based around the UN Global compact standards for environmental compliance, human rights and labor practices and anti-corruption (Foster + Partners, 2014).

Sustainable Design Achievements:

The criteria set by Sustainable Specification helps to ensure projects include intelligent material choices, reduce incidents around health and safety, and non-compliance on site. These include:

- Low or no added urea formaldehyde in wood products
- Preference for regional, recycled and responsibly sourced materials
- Materials with low VOC content
- No use of EPS or Polyurethane insulation
- Include installation and safety information on all harmful and hazardous materials (Foster + Partners, 2014).

Foster approach to Masdar:

Building relying on the history of this nation and taking the adventure to the future with knowing your past is what Foster has planned for Masdar. He believes in embracing the history, being more symbolic, expressive, and powerful. In other words being something more than just an empty gesture, but a powerful pointer that represent the country is as important as achieving a zero energy city (Foster, "Masdar City, Abu Dhabi: the gulf between wisdom and folly", 2010). The architecture, which makes the 150 degrees temperature tolerable, became the subject of the Foster study team in order to gain its secrets (Foster, In Arabian Desert, a Sustainable City Rises, 2010).

Design Board

The Design board, led by founder and Chairman Norman Foster, Stefan Behling, Grant Brooker, Nigel Dancey, Spencer de Grey, Gerard Evenden, Luke Fox, Paul Kalkhoven, David Nelson and David Summerfield, reviews each project from the very beginning, ensuring the continuity and quality at every stage of a project by taking full responsibility for design, as well as encouraging the sharing of expertise across the project teams. Challenging and being challenged is the character of the Design Board. As well as stimulating research, arranging cross-disciplinary design workshops on various issues, such as urban design and sustainability (Foster + Partners, n.d.).

The “Foster + Partners” headquarter is located on Riverside, London. Although this district is where the work tends to be focused, the firm is a multinational organization that has a worldwide application (Foster + Partners, n.d.).

2-Environmental consultancy Mott MacDonald

In the year 1989, two long-established and well-known international engineering consultancies – Mott, Hay & Anderson, which were famous for their contribution to transportation engineering merged together and formed The Mott MacDonald Group. Starting in Croydon, United Kingdom, the company focused on progress toward the evolving organization, which led them to the legacy of operating from 180 principal offices in 50 countries across 12 core sectors - buildings, communications, education, environment, health, industry, international development, oil and gas, power, transport, urban development and water (Mott MacDonald, n.d.).

Mott MacDonald and UAE

Mott MacDonald and United Arab Emirates cooperation, using vast skills and experiences, dates back 50 years and as a result, this group has been one of the main contractors in UAE projects ever since, including Um Al Nar power and desalination plants, Masdar City, phase one of Dubai Marina, Jumeirah Golf Estates, Palm Jumeirah Monorail, the Emirates Float Glass Plant and Abu Dhabi's Surface Transport Master Plan to name a few (Mott MacDonald, n.d.). This company has been assign as the lead designers for all infrastructures of the 2.2 million square miles on what is set to be the world's first carbon neutral, zero waste cities, Masdar (Hansford, 2009). One of the recent projects the Mott MacDonald has done in UAE, being the technical advisor is Shams power project, a renewable energy harvest where 100MWe installation of parabolic mirrors are installed in order to gain the thermal energy of sun (Mott MacDonald, n.d.).

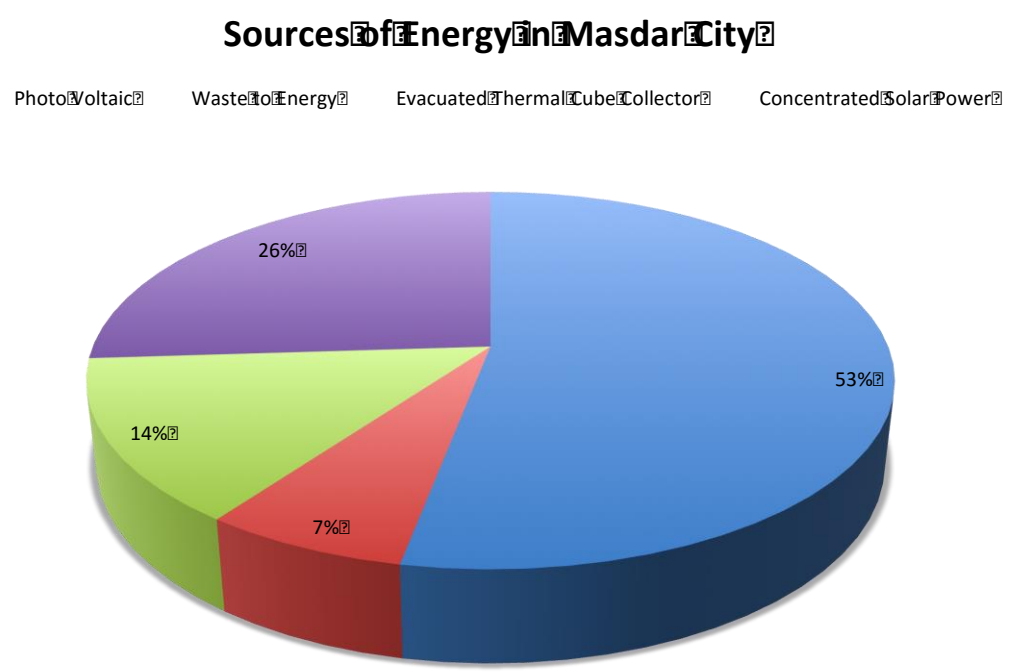


Fig1: Sources of Energy in Masdar City
Photo Voltaic (Shams 1 Power Project) provides more than half of the energy of Masdar

Masdar is aimed to be %100 powered by renewable energy, while 170 MW (%53) of the total energy usage is provided by Photo Voltaic. The energy usage in Masdar City is supposed to be less than 30 KWh per capita per day, an amount which is 9 times less than the energy usage in USA (Barlow, n.d.).

Group Board

Keith Howells, the chairman since January 1st, 2011, Mike Haigh, head of the Europe, Africa and UK section since February 2013, Kevin Dixon, head of Asia and Australian Section of the company since January 2009, Guy Leonard, the Group's strategic development director since July 2014, Ed Roud, the finance director of the group and Kevin Stavell, the Group's strategic development director unify the Group Board of the Mott MacDonald Company, according to the Mott MacDonald Group, the vital element of companies assets, the quality of the employers and the employee-owned business (Mott MacDonald, n.d.).

Project Description:

Masdar city, the first project relying to only sustainable resources in a city scale (Bullis, 2009), is located at 24.4202° N latitude and 54.6132° E longitude (Zwiefelhofer, 2008), just 17 kilometers (11 miles) to the east of Abu Dhabi, a mega city located in United Arab Emirates, Middle East, Asia (Bajaj Kapil, 2014).

24.4202° N latitude
54.6132° E longitude

Fig 2: Masdar City in the regional context

Fig 3: Masdar City relation to Abu Dhabi

The site which Masdar city is located was originally a plant sales outlet which as time passed, turned in to a salt flat. The site has been suitable for large amount of construction because of sweet sand (a waterproof sand, which can help with saltwater erosion and the maintenance of groundwater levels and salinity) imported into the area (Masdar Corporation, 2012).

As the population of the world grows, the demand of energy rises. This nonstop rise of demands for energy and the fact that oil isn't an eternal source of energy have created a global demand for alternative energy sources. Therefore, sustainable development is no longer just an option; it is the only way forward. Hence, the leadership of Abu Dhabi wants to prepare the emirate for the post-oil age (Reiche, 2010).

Using both modern technology and traditional Arabic architecture together in order to achieve the maximum energy efficiency, Masdar can become a pioneer and a role model for the cities of the future (Masdar Corporation, 2012).

Masdar City's construction site consists of two phases, two squares which connect together and forms the whole city. After three years of working, the first piece of development with the budget approximately $1.4billion was completed. The development consists of six main buildings, one street, 101 small apartments (Vidal, 2011) ,where is the home to the students and the academics of the offshore campus of the Massachusetts Institute of Technology (MIT) live (Foster, In Arabian Desert, a Sustainable City Rises, 2010), A large electronic library, and the Masdar Institute. The phase two, which was originally supposed to be finish by the year 2011, featuring 222 more apartments, and more streets and shops (Vidal, 2011), was pushed back to year 2025 due to the global " clean tech" market stalls in repression (Nambiar & Gonchar, 2011).

While Masdar has a strong road and rail connection between other cities and the international airport, the city itself is vehicle free in the street levels, as the streets are designed to be all pedestrians, the underground public transportation, helps people to travel through the (Foster + Partners, n.d.).

Using the natural resources (e.g. photovoltaic farms), it was estimated that Masdar City would operate entirely self-sufficient (Foster + Partners, n.d.). The criteria which unfortunately was met as one fifth efficient as it was supposed to be due to the dust storms and haze (Sari & Ara Karim).

Objectives:

With the lack of natural resources, fresh water in particular and the population growth in UAE, (Cugurullo, 2015) preserving every resource such as water, energy, and food supplies among with the uncertainties of climate change and a globalized economy in order to guarantee their "ecological security" is a crucial process (Lau, 2012).

Masdar is planned to be a zero carbon, zero waste city. A city with sustainable transport, sustainable materials, sustainable food, sustainable water, habitats, and wildlife, culture and heritage, equity and fair trade, and health and happiness (Crot, 2013).

Masdar city is raised on a 23 foot-high concrete base to maximize its exposure to winds, using the natural ventilation as a source of cooling (Bajaj Kapil, 2014). In order to have the maximum efficiency of the wind in the region, a supersized wind tower is installed in the public square, which uses convection of a wind flow to mollify the heat, bringing thermal comfort for the people at the plaza, (Zarandi, 2009).

The Teflon-coated wind tower in Masdar City, Source of natural ventilation
Image courtesy of Ali Haidar/EPA

The Skylight illumination through vestibules planned inside the Masdar buildings prevents direct sunlight and associated heat from penetrating into the space. As night air flows into the lower floors through grills, it cools down the room temperature while hot polluted air vents out of the roof- level openings vents out via the stack effect. Thermal mass walls conceive the cool at night and release it through the day, keeping the temperature modulated over the course of the day. In order to use the maximum daylight in the buildings, while avoiding the solar heat gain and glare in the rooms, a glass-reinforced concrete latticework, is installed on the windows of the building to shade the curvy balconies (Nambiar & Gonchar, 2011).

Low-raised buildings and a relatively high density are the two main scheme of the Masdar City urban pattern .The design of upper stories over the first floor in the residential buildings, forming an undulating balconies and narrow cantilevers, along with photovoltaic panels fixed on the roofs are implemented to maximize shade and reduce temperatures from direct sun exposure without compromising the movement of pedestrians or light motorized vehicles (Hassan, Lee, & Yoo, 2015).

Undulating balconies and cantilevers in order to make shade in the street.
Masdar City, United Arabic Emirates.
Image courtesy of Dr. Khosrow Bozorgi

The orientation of the streets is influenced by the flow of the dominant wind in the region. The layout of the streets follows the environmental needs. Grids shape the streets of the city with a limitation on the width, which results in shady and cool walkways in the hot days (Hassan, Lee, & Yoo, 2015). There is a step back designed under the colonnades at the edge of short streets that turn and change direction located at the ground floor of the buildings. This type of design, which is actually derived from the old traditional Arab settlements, helps accelerate the movement of air (Nambiar & Gonchar, 2011).

In Addition to the design and architectural features of the city for adjusting the thermal performance and providing cool shades in the public spaces, courtyards have been designed as a gathering place which also creates assorted spaces of air density that encourage ventilation, and a private environment, further shaping a social, secure area for residents to meet and converse outdoors (Hassan, Lee, & Yoo, 2015).

Courtyards, providing shades and comforts as a social gathering place.
Yazd, Iran
Image courtesy of Mahdi Afkhamiaghda

Site Climatic Context

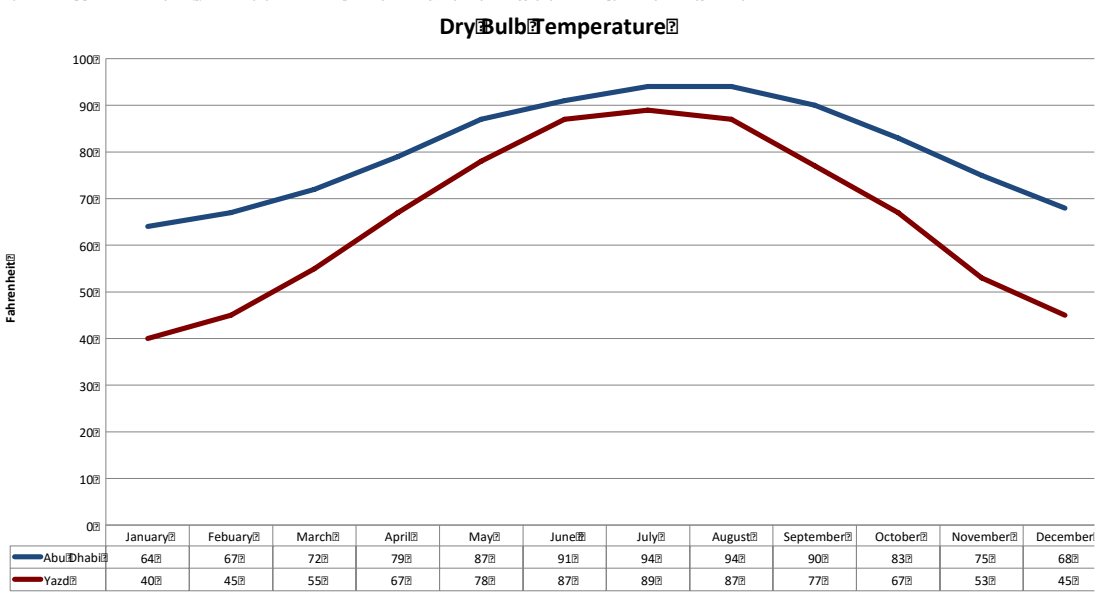
Data availability and sources

For the purpose of climate analysis and thermal simulation, data has been taken from the U.S. Department Energy Database, collected from 412170 (IWEC) Abu Dhabi International Airport and 408210 (ITMY) Yazd International Airport WMO Stations. Unfortunately, the nearest weather report station to Masdar City is the Abu Dhabi international airport, which is 6 miles away from the Masdar City boundary.

The files, which the Adaptive Comfort Model in ASHRAE Standard 55-2010 was used in order to generate design conditions, are listed below:

http://apps1.eere.energy.gov/buildings/energyplus/weatherdata/2_asia_wmo_region_2/ARE_Abu.Dhabi.412170_IWEC.zip

http://apps1.eere.energy.gov/buildings/energyplus/weatherdata/2_asia_wmo_region_2/IRN_Yazd.408210_ITMY.zip



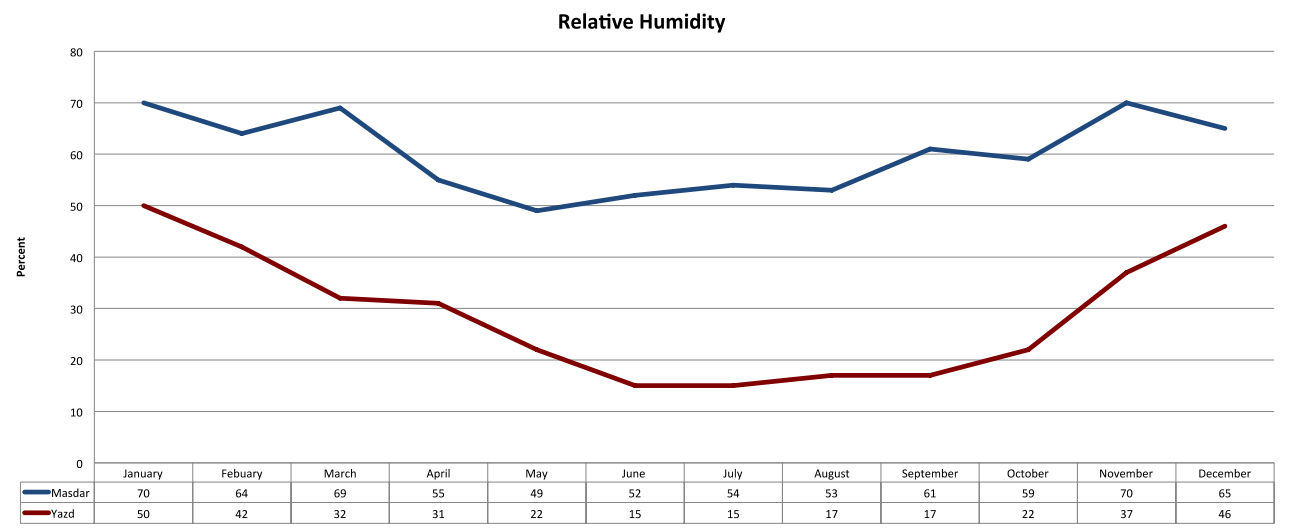
	January	Febuary	March	April	May	June	July	August	September	October	November	December
Abu Dhabi	64	67	72	79	87	91	94	94	90	83	75	68
Yazd	40	45	55	67	78	87	89	87	77	67	53	45

Fig 4: Comparison between the dry temperature of Yazd and Masdar City

Masdar and Yazd have a sub-tropical, arid climate. Chart 2 indicates that the temperature fluctuation in Yazd from January to December is more than Masdar, which implies that unlike Masdar, Yazd possess aggressive weather changes through the year.

According to the above fig, temperature on average in Yazd varies from as low as 40° F during the winter to as high as 87° F during the summer, while the temperature in Masdar City stays between 64° F and 94° F. This indicates that unlike Masdar, which is hot all year long, Yazd has hot summers and cold winters; therefore, different strategies for the passive cooling and heating in different seasons would be needed.

Temperatures are frequently beyond comfort during the summer in both Yazd and Masdar. The most comfortable conditions in Masdar are found in the March, April and November when temperature is around 70° F and 80 ° F in. However, the comfortable moths in Yazd are only April and September.



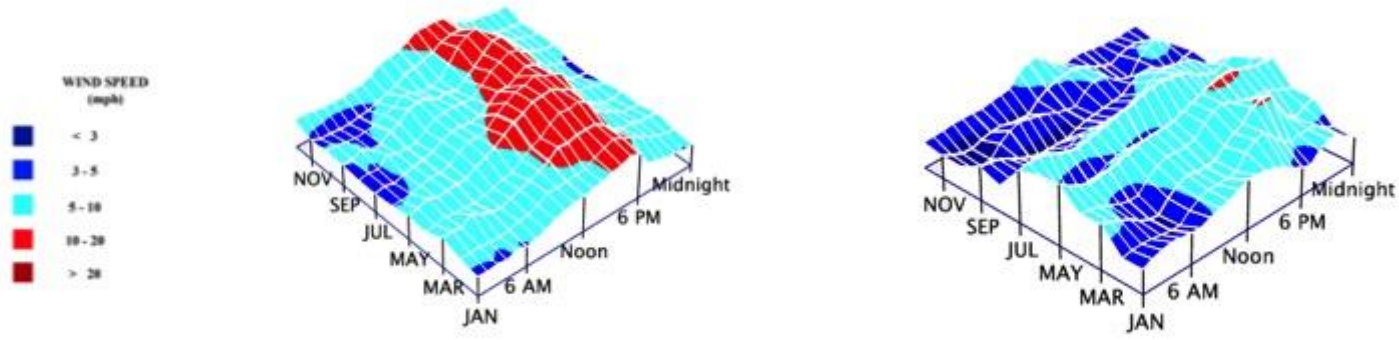
	January	Febuary	March	April	May	June	July	August	September	October	November	December
Masdar	70	64	69	55	49	52	54	53	61	59	70	65
Yazd	50	42	32	31	22	15	15	17	17	22	37	46

Fig 5: Humidity comparison between Masdar city and Yazd

One of the most important differences between the climates of these two cities is that Masdar is considered a city with high humidity, while Yazd humidity is always below the comfort zone. As moisture holds a significant amount of energy referred as latent heat, (Autodesk, n.d.) saturated air with humidity makes being in outdoor during the hottest months (July and August) really uncomfortable.

According to a study by John Hopkins researchers, inhaling hot air can impair and weaken breathing disorders and promote airway irritation, where the hot air contracts the airways, making it harder to breathe, and causes shortness of breath. (Editorial Staff at Healthcommunities.com, 2013).

Masdar have a low density of wind during the year (Figure 1). The yearly average wind speed is nearly $4.3\frac{m}{s}$. Because of this low density, there are three louvers at the top of the tower, each one facing different direction in order have the best efficiency in using the wind with low density which open in the direction of the prevailing winds and close in other directions (Isam Janajreh, 2010).



A B

Fig 6: 3D Chart of monthly average wind speed for A) Masdar City B) Yazd

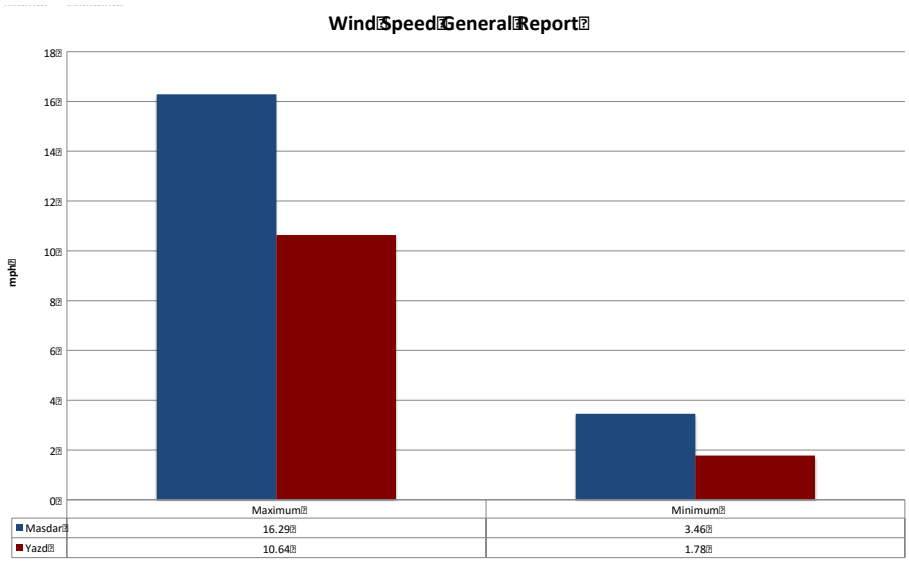


Fig 7: The Wind Speed General Report

Using local material and environmental amenities in the architectural design would result in better financial, economic and resource team. Wind towers, a ventilating shaft with openings towards the promising principal wind in order to capture air from above and transmit it indoors (Foruzanmehr, 2012) and courtyards in Yazd which would provide regulate thermal performance, cool air and shade to the surrounding areas, while creating assorted spaces of air density that encourage ventilation would be an architectural design which would help reducing a lot of energy demands.

Wind towers in Yazd, Iran
Image courtesy of Mahdi Afkhamiaghda

Masdar has distinct seasonal and daily patterns in wind (Fig 8). Generally from around 8am through to 8pm, when land heats up during the day more quickly than water (Energy Design Resources by Architectural Energy Corporation, Boulder, CO), there is a dry air rising from the north west bringing dusty air from the desert to the interior south with typical wind speeds of c. 2.5m/s (pha consult, 2008).

At the night, the wind turns, rising through east to north-northwest carrying a cooler, due to the loss of the radiation in night and more humid air -rom over the Persian Gulf at higher speeds – typically 4.2m/s (pha consult, 2008).

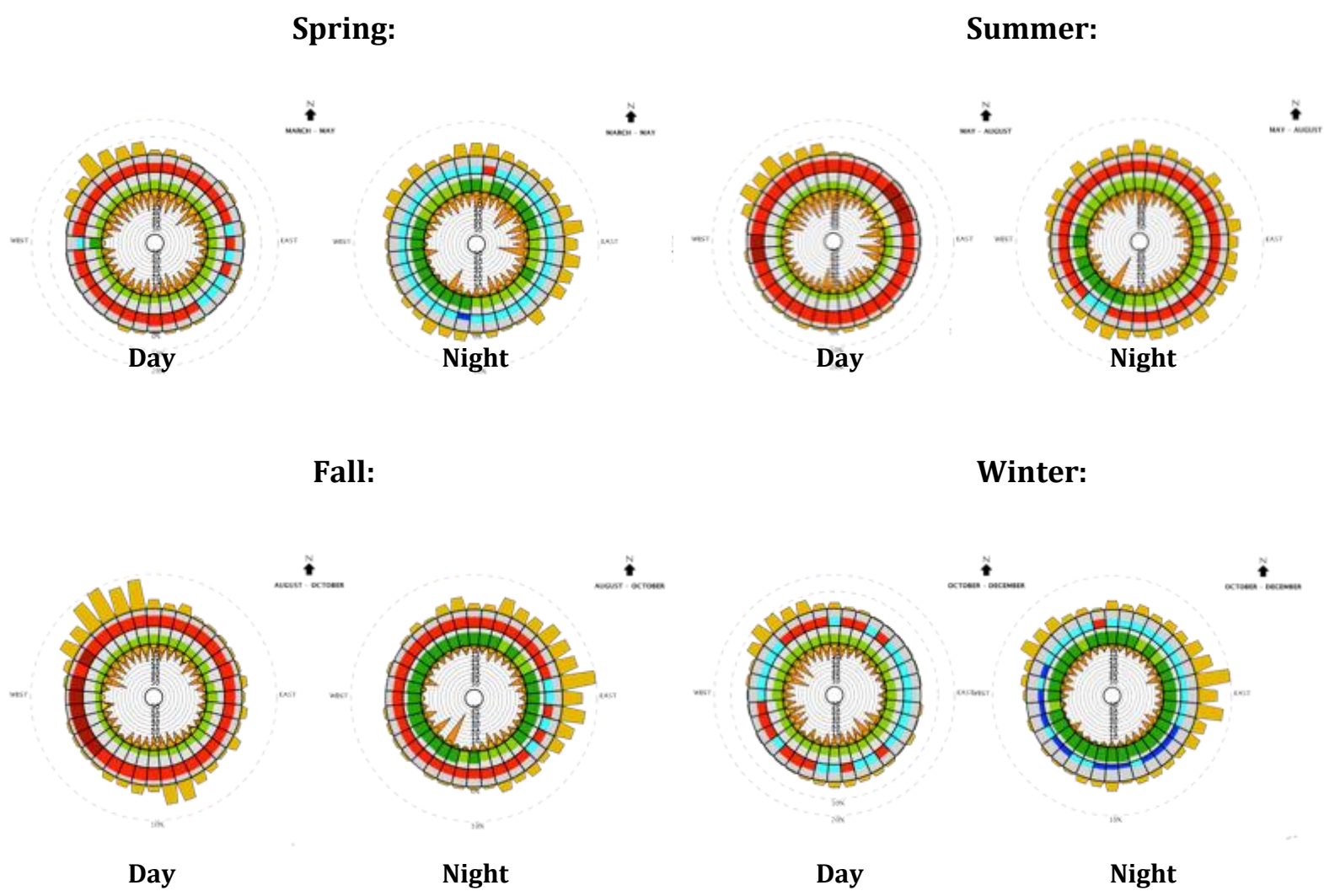
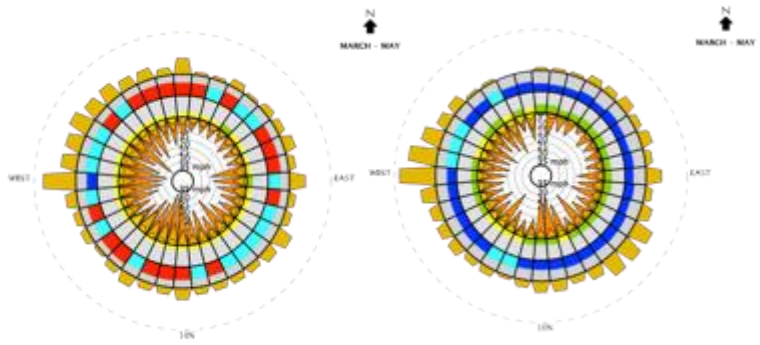


Fig 8: distinct seasonal and daily patterns in wind in Masdar City

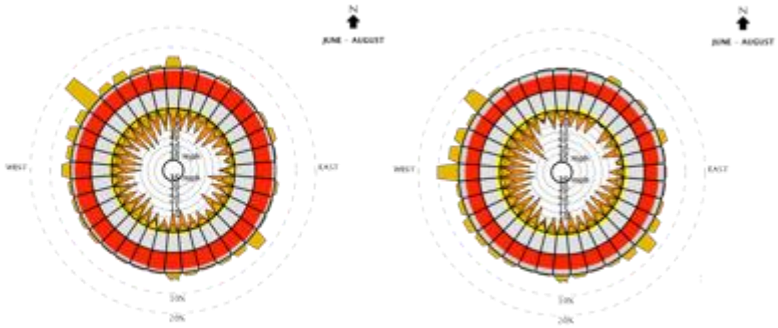
Yazd is located in dasht-e- kavir desert in middle of the Iran. The distinct seasonal and daily patterns in wind in this city often carry dusty air coming from northwest and southeast (Fig 9).

Spring:



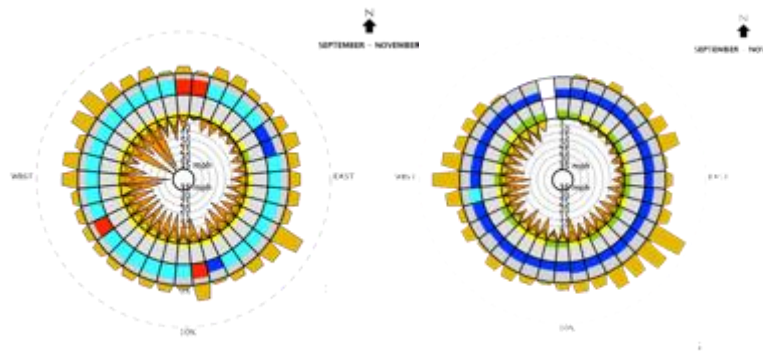
Day **Night**

Summer:



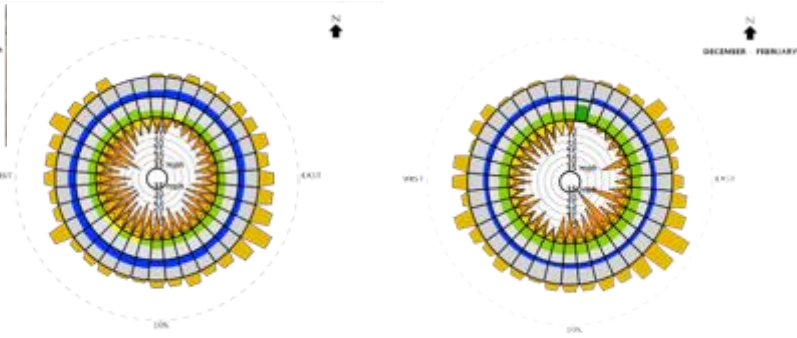
Day **Night**

Fall:



Day **Night**

Winter:



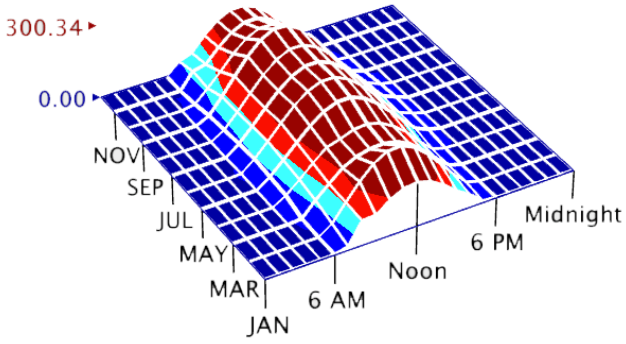
Day **Night**

Fig 9: distinct seasonal and daily patterns in wind in Yazd

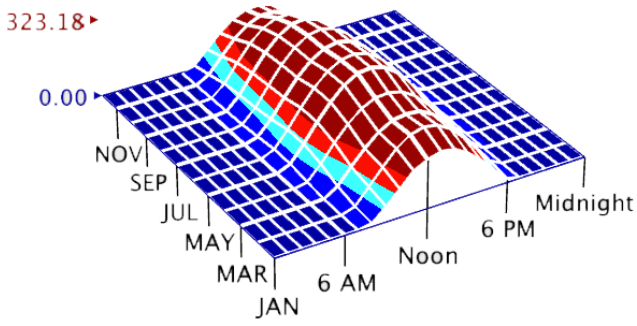
Wind catchers help creating a pleasant ambiance by exchanging the air in the room with the new, fresh breeze of the outside (A'zami, 2005) .As the wind hits the wind catcher, a positive pressure is made while on the opposite side of the wind catcher a relative negative pressure would be genesis because of the absence of any wind (Abeini Rad, 2014).

The wind catcher opening facing the upcoming wind brings the outside fresh air into the building and creates an air circulation in the building, while the blades on the other side of the wind catcher, pulls the hot and polluted air out of the building into the sky (A'zami, 2005). This air circulation, which is the result of stack ventilation where lower air pressures at higher heights can passively pull air through a building, (Bahadori , 1994) is unique to the Yazd climate. In the hot and humid cities like Masdar only one side of blades in wind tower there is open at the time facing the dominant wind while other louvers are closed.

Thanks to the high amount of radiation in Yazd (Fig 10), when there is no wind blast, the side of the wind catcher which faces the sun gets hot, making the air rises according to the stack ventilation. This air rising out through the wind catcher makes a kind of proportional vacuum, which results in sucking the cool air on the other side opening (Fig 11).



A)



B)

Fig 10: Tilted Surface Radiation in A) Yazd B) Masdar

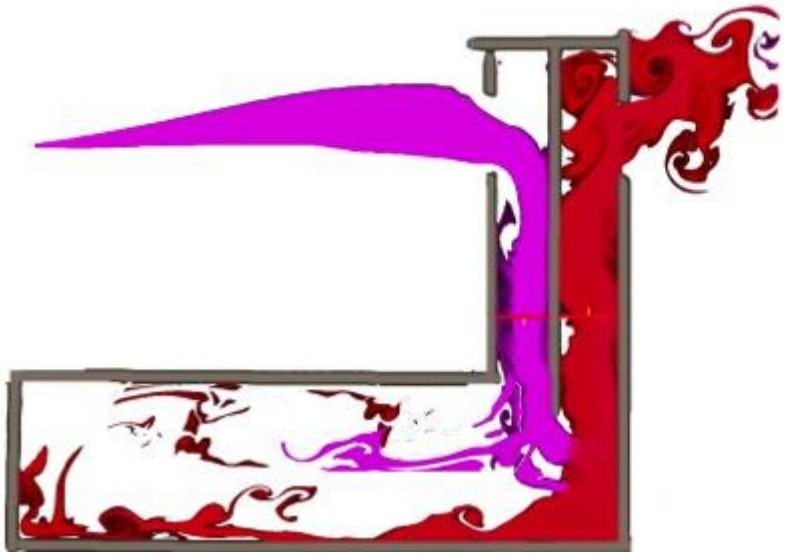


Fig 11: The lower Pressure air pulls air through the building

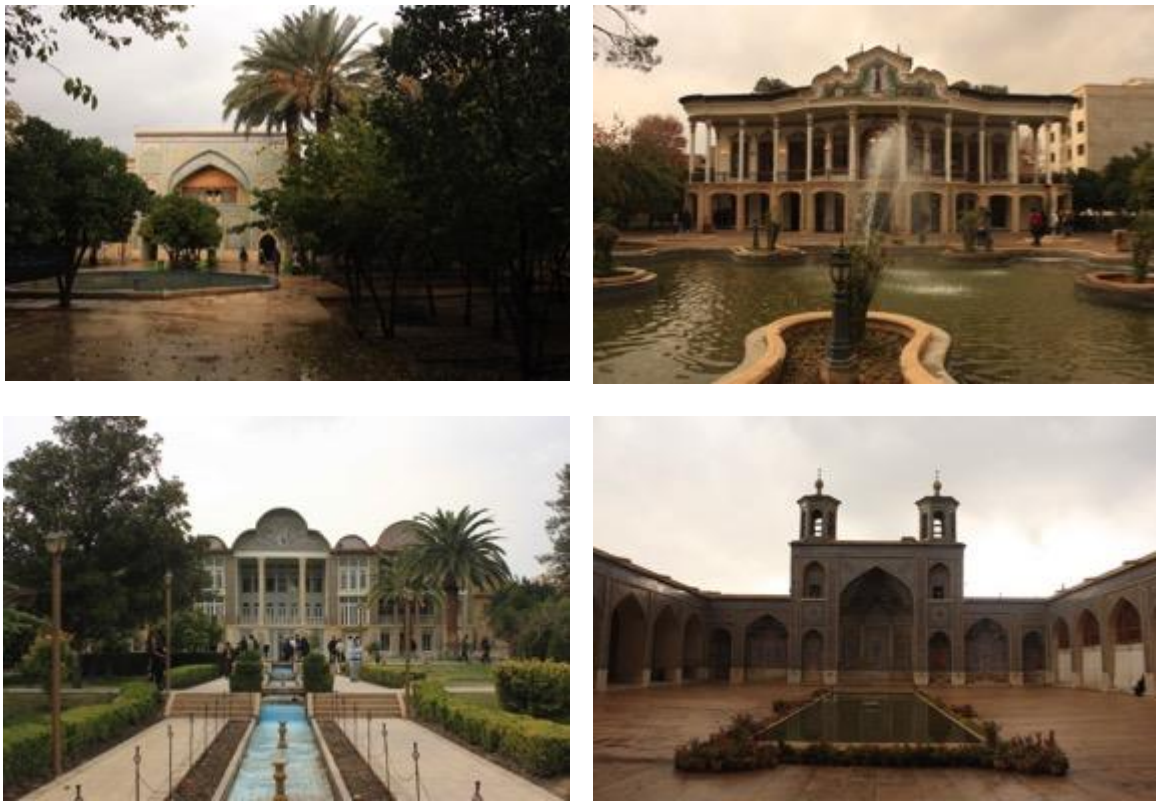
As being surrounded by deserts and the lack of humidity, evaporate cooling plays a huge role in the cooling process in Yazd. This cool air will be provided either by a small pool which the hot and dry air hits as it comes inside, gets cool and flows into the area or by wet, cool mats that are hanged up in the wind catcher opening which increase the moisture in the incoming air and flows it down (A'zami, 2005).

The saturated mats, hanged by this sticks cool down the flown hot air, sending it inside.
Image courtesy of Mahdi Afkhamiaghda

Due to the dusty air and the need of access to fresh air, Wind-catchers are actually higher in hot and dry climates like Yazd compared to hot and moist areas as in Masdar (A'zami, 2005).

Courtyards are another example of a passive architectural system, while interacting with both interior and exterior space and using natural landscape and planning in order to cause shading, courtyards are a key component to achieve thermal comfort in a place without a use of mechanical system (Nasim Karizi).

Water heat capacity is more than surface, which means it makes much more solar energy to heat up the water in day, just like it would take a lot of energy to cool down in nights. Using this fact, the water has been the axes of design in vernacular architecture, one crucial element that needs to reuse again in the city in order to help the city live (Energy Design Resources by Architectural Energy Corporation, Boulder, CO).



Water; the center of the desert life
Image courtesy of Mahdi Afkhamiaghda

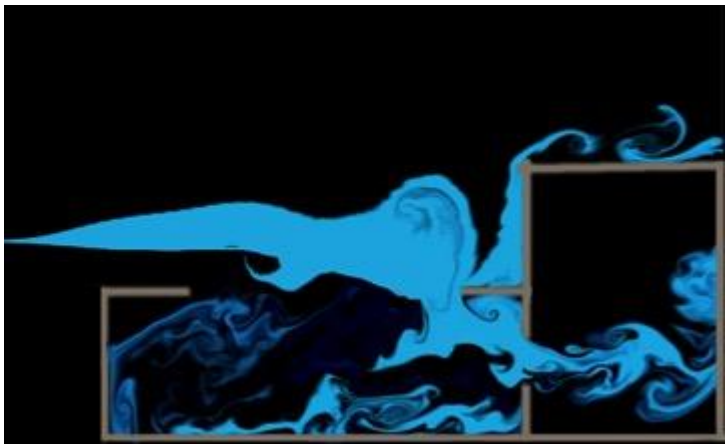


Fig 12: The stack effect caused by courtyard

As a result of high amount tilted surface radiation in both Masdar and Yazd, shading is one of the vital features used in the architectural planning. Narrow streets with limitation in width and buildings with undulating balconies just like Masdar, allows daylight to enter the street spaces, but keep the daylight to a minimum so it won't be any harsh (Nasim Karizi).

Narrow streets, which cause delightful shading pathways
Image courtesy of Mahdi Afkhamiaghda

The vernacular urban planning and design strategy in dry-arid cities such as Yazd was focused on neighborhoods with high density and less sprawl, surrounded by narrow and irregular alleys. By building very densely they could protect the people from extreme weather conditions without the use of any mechanical equipment running by fossil fuels (Abeini Rad, 2014).

Providing daylight while preventing the undesirable heat and glare is one of the important subjects in hot and arid climates with a high amount of solar gain radiation. Considering climates issues like orientation, location and wind direction in buildings are the important factors that architectures should rely on (Nasim Karizi). Using small windows in the south equipped with curtain and shade helps bringing the daylight in, while in the meantime prevents the unsolicited heat and glare (Fig 13).

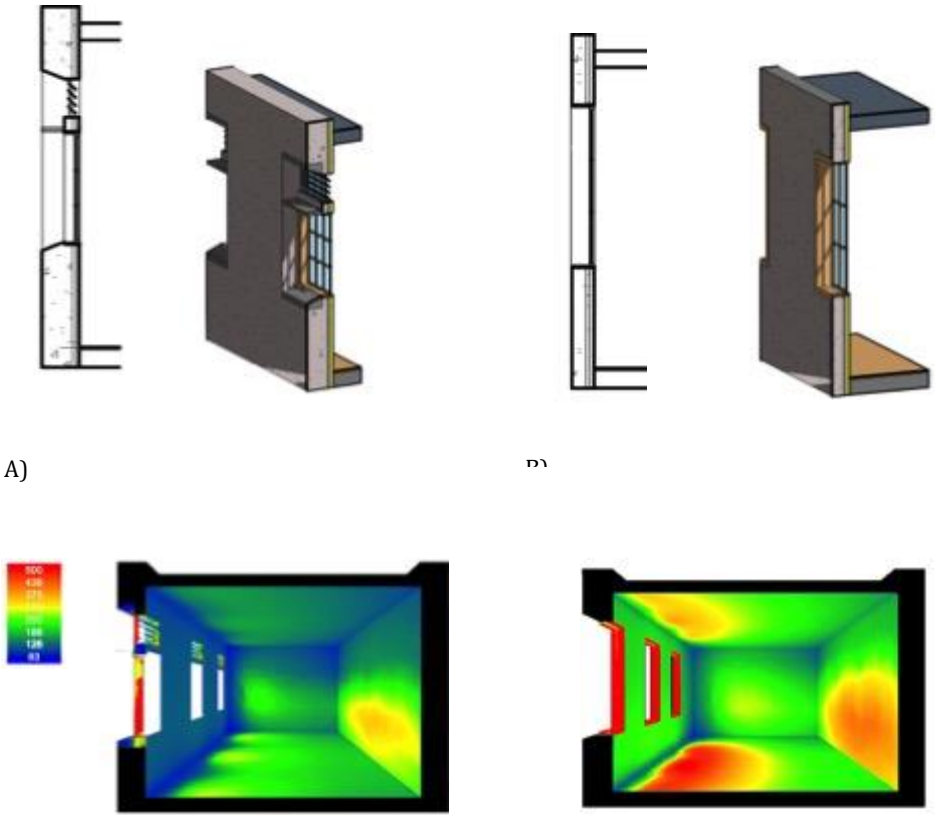


Fig 13: The Daylight amount comparison between:
A) windows with louvers and shade B) Typical windows position

By proper orientation of the buildings according to the sun path in a large scale as city and using north and south face of the building for the main activities, we can achieve the maximum use of day lighting.

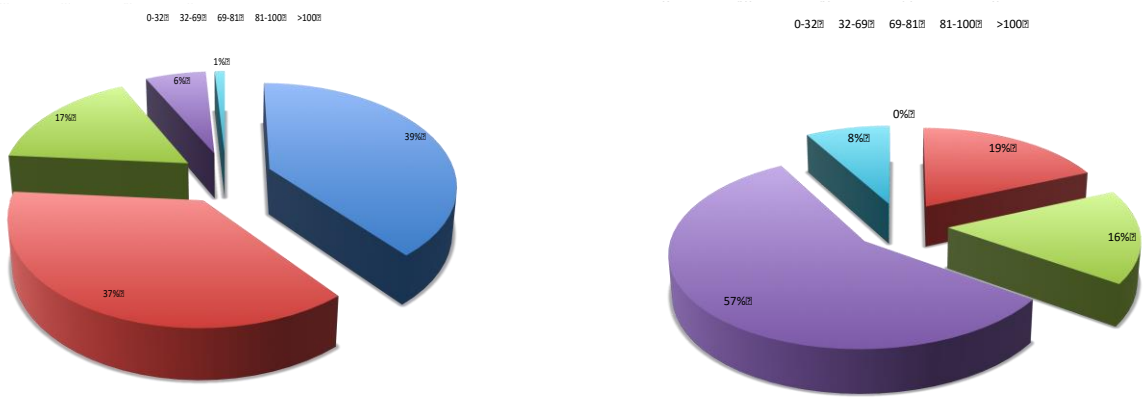
The best design for the buildings in climates like Yazd would be an extended shape with the east-west long axis in order to use the daylight. If this extended area becomes a square or in other terms our space gets deeper, we need to make our ceilings higher or we can use skylights (Innonative Design).

Having high ceilings in Yazd is not only solves the problem of day lighting, but also by having some opening at the top of the walls, we can provide the ventilation needed in the room (Innonative Design).

Using high ceiling and openings for the natural light and the ventilation, Yazd, Iran
Image courtesy of Mahdi Afkhamiaghda

Since there is a significant temperature swings between day and night in desert (Fig 15) thermal mass plays a vital role in the performance of buildings.

Thermal mass describes the capacity of materials to absorb, store and release heat. Thermal mass strategy defines how the mass of buildings reacts and modifies the temperature while it fluctuates between day and night. During the day when the exterior temperature rises, thermal mass absorbs the outside heat more slowly compared to the routine materials. As the day passes, the thermal wall reaches its maximum capacity and then, it starts to release the warm to the interior while the exterior is gaining the cold temperature, and this cycle continues through day (Abeini Rad, 2014).



A) B)

Fig 14: Temperature distribution through a day in A) Masdar City B) Yazd

In hot dry-arid climate, comfortable temperature in the ground can be reach in a good depth (13.12 feet), where the earth stays near the annual temperature here. However in humid places like Masdar, due to the earth dampness and the possibility of mold growth, reaching below the ground would not be the best strategy.

Therefore as we still can see in the city, basement is a main part in the vernacular architecture in the Yazd region because of the earth heat load saving in very hot-dry climates.

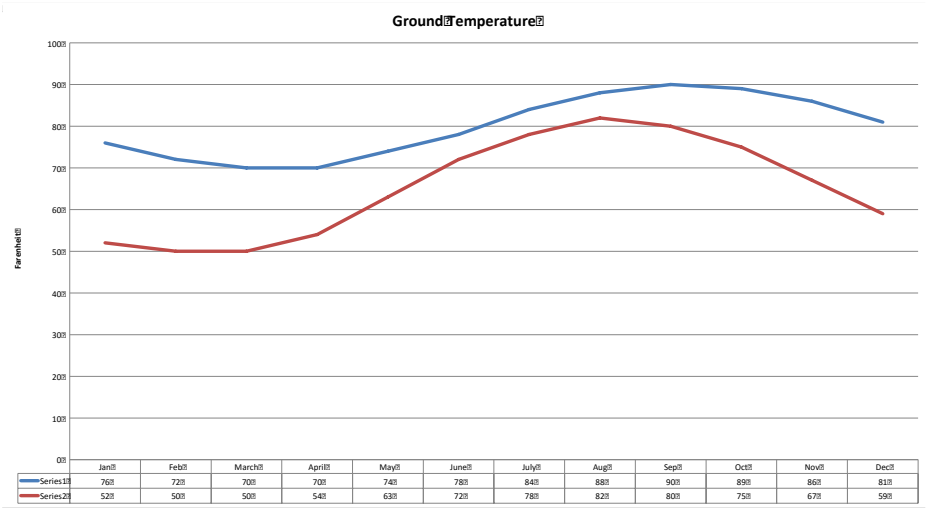


Fig 15: Ground Temperature comparison between Yazd and Masdar City

While Masdar is built with the purpose of being a net zero energy city and it uses the latest technology in each and every aspect, Yazd, is considered as an old city with so much history. Although Yazd can't be as pliant as Masdar in changes, by applying some amendments to the building designs and the street patterns sustainability can be achievable in Yazd, where due to its severe climate condition, using natural resources instead of fossil fuels and eco-friendly building design can make a delightful ambiance in the city. One of the biggest advantages of Yazd compared to Masdar is that the city was built for people and by people, the city formed by the need of people. Unlike Masdar where the priority has been profit and lucrative, therefore economy and business that has been prior to social life (Cugurullo, 2015).

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