# Developing Vernacular Passive Cooling Strategies In (Kurdistan-Iraq)

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**Abstract:** Vernacular design strategies can be identified and adapted to improve the energy performance of modern architecture in Kurdistan. This paper focus on some passive cooling strategies that were used in hot climate to reduce the use of energy for cooling, and enhancing a green architecture. Furthermore, the main purpose is adapting architecture to the climate environment through modernization passive ventilation solutions for building, trying to achieve this goal by analyzing some of the traditional natural ventilation strategies. Moreover, improving the effect of using natural ventilation on reducing cooling load through utilizing the vernacular principles for cooling. In addition, showing some examples of using the vernacular ventilation strategies that are common in Kurdistan in the modern buildings and on the city level explain the possibility to adapt them by application of some design elements and high technology devices. Finally, showing the effectiveness and applicability of these strategies in the future and sustainable building in Kurdistan.

**Keywords:** Passive cooling, Vernacular architecture, Natural ventilation, Sustainable buildings.

## 1. INTRODUCTION

1. **Climate and environmental aspects:** There are various factors needed consideration in designing buildings that relates to the indoor environment such as, orientation, materials, location and the characteristics that related to providing comfort climate for occupants with considering outdoor climate implementing some principle of natural ventilation and cooling strategies may effective especially in hot –dry climate Vernacular architecture in hot, arid regions is characterized by energy efficiency. Therefore, adapting energy efficient vernacular strategies improves contemporary architecture such as thick walls, natural ventilation from the courtyard, wind towers, stack ventilation. Traditional architects of the hot and dry climate presented numbers of logical methods into the building to provide thermal comfort for residents. Those methods can be evaluated and implemented into the contemporary buildings. integrated them with a help of the technology when traditional solutions are not enough [1]

2. **Space Cooling by natural ventilation:** Ventilation is the most effective and simplest method to provide indoor thermal comfort, even in the hot climates for some specific period when the natural ventilation could be a favorable option to achieve thermal comfort. Ventilation may have a positive impact on energy demand in summer because by increasing air flow the indoor temperature is decreased. Consequently, cooling load will fall. Moreover, it will be more effective with using new technologies some maintains and electrical energy are needed [2].

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### 2.1. Traditional solution for minimizing solar gain:

#### 2.1.1. Courtyard:

courtyard is one of the most significant feature of houses in middle east and Kurdistan plain regions vernacular architecture, it is surrounding by continues or semi continues walls for other living spaces, which mediates the house, and the area is open to all the rooms surrounding it since it is the source of lighting and air as well (Fig. 1). The most prominent factor in hot climate is the temperature, especially during the hot summer. Therefore, using the system of inner courtyard was used since ancient times tried to address climatic conditions of surroundings, as well as the blazing sun so the treatment came via isolating within the home on the outer perimeter. Creating an open environment inside the building allow the free movement of airways and the continuation of the air even in case of in poor air movement in the outer space of house. by common method upward movement of hot air, and that the creation of a difference between the temperature of the airways layers, [3] After studying the courtyard's orientation, a north to south orientation is usually the most favorable in the Middle East because its orientation will affect its ventilation. Moreover, it should be situated to react favorably with climatic at different times of the year. In the summer, the courtyard should receive enough light, but also have enough shade to keep a cooler temperature.

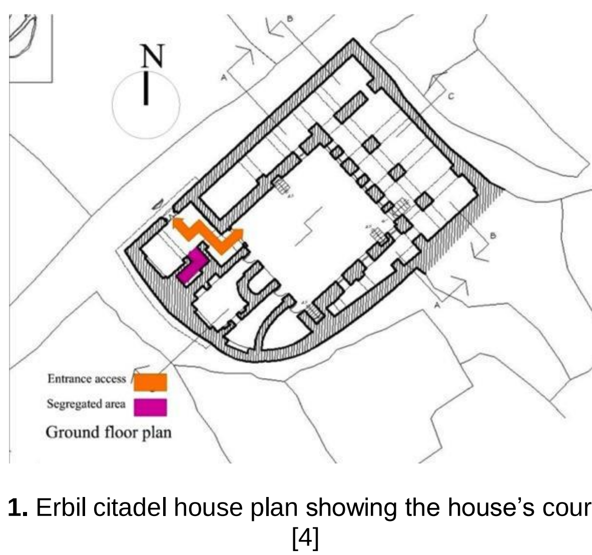


**Fig. 1.** Erbil citadel house plan showing the house's courtyard. [4]

In the summer and inside the courtyard house some cycles of the temperature is experimented. The first one starts at night when the cool air flows into the courtyard and the surrounding rooms. After noon the temperature increases gradually but the thick walls of the house prevent the heat from penetrating inside the house, which helps maintain the indoor temperature. However, at late evening rooms lose their cool air when the outdoor floors, walls and the courtyard become warm [4].

**2.1.2 Interceptions' elements:**

**Natural element for shading**
The courtyard is one of the most important places to achieve efficient shading. Therefore, in traditional courtyard houses in hot-dry climates trees as interception devices protect buildings from direct sunbeams and make shady area within the courtyard and on the building walls (Fig 2).

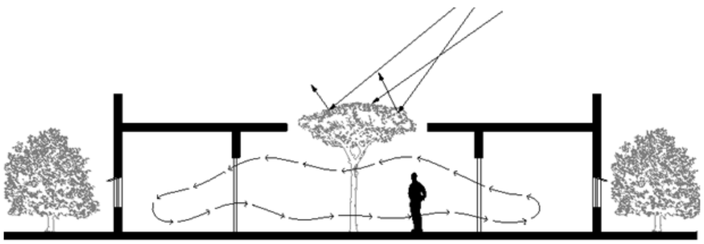

***Fig.2.*** *Using natural element for shading [1]*

In addition, inside the traditional house the courtyard is usually surrounded by two stories at a height that allows sunlight to reach parts of the courtyard floor for a period of time, determined by the shape of the courtyard and the proportion of the wall height to the width of the courtyard [4].

**Porticos:** The portico is a vernacular element that provides shade to the courtyard by surrounding it on at least two sides. The portico is most efficient when placed on the northern and southern sides of the courtyard [Fig. 3]. Moreover, because the house surrounds the courtyard, a portion of the courtyard remains shaded throughout the day, preventing the house from getting warm until late in the day the shaded area produces cool air that flows into the ground-level rooms and replaces the warm air, which is rising [4].

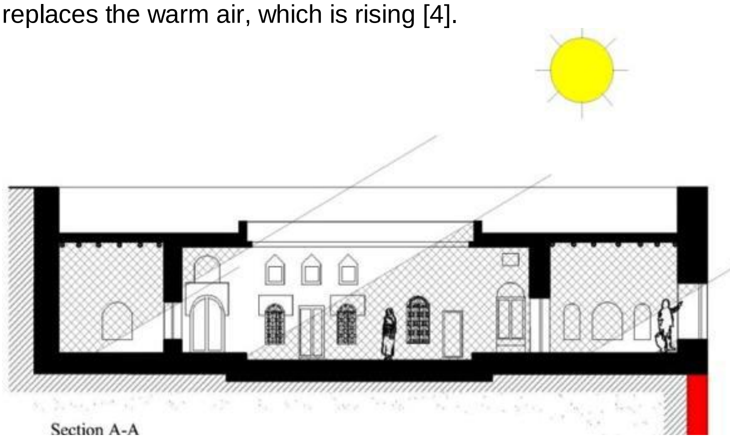


**Fig.3.** Erbil citadel house cross-section. [4]

**2.1.3 Ewan:** It is a covered hall with three walls (between two rooms) and the fourth side is completely open to the fresh air and overlooking to the inner courtyard. It has higher roof from the other rooms Fig. 4. Sometimes the level of it is floor and the other adjacent rooms is higher from courtyard floor about one and half meter to give space for cellar windows to open on courtyard for lighting and ventilation [3]. Sometimes by adding chimney natural ventilation can be achieved. Ewan is oriented mostly to the south or the east of house to prevent the heat from the afternoon sun, this orientation gives priority to use as a sitting, resting, dinning space.

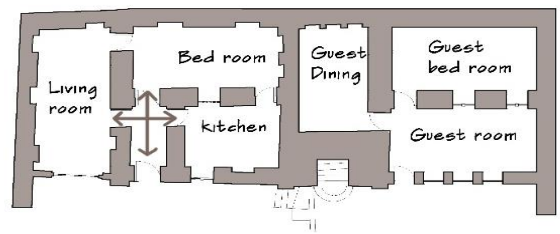


***Fig.3*** *Ground floor plan of vernacular houses in Sulaimany.*

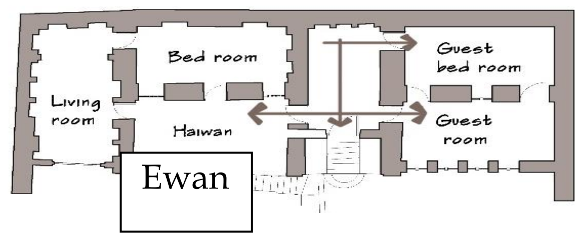


***Fig 4.*** *First floor plan of vernacular houses in Sulaimany showing Iwan .*

## 3. Ventilation strategies in vernacular architecture:

Ventilation appears as a logical and suitable strategy for many types of buildings. Great deal of air flow is needed for summer thermal control of the building in hot climate.

**3.1 Stack ventilation**: stack ventilation has been introduced as the upward movement of air through openings in a building fabric and happens as a result of having different air pressure, cooling air enters through the lower opening of the building and hot air go out by the upper opening such temperature differences are usually a result of the heating by the occupants, lighting and other internal heat source. It depends on the height of the building. the ventilation area may be maximized by increasing the vertical distance between the inlet and outlet [5].

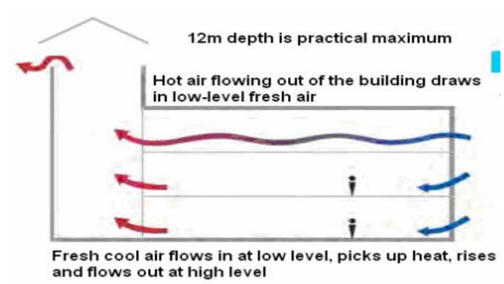


***Fig.5*** *Natural ventilation mechanisms from (GreenDatabase.org)*

This principle makes this ventilation strategy less dependent on outdoor wind condition and makes it more significant to improve natural ventilation in a building with limited side openings. Because of these advantages, many researchers and building designers are prompted to design and develop several innovative stack ventilation strategies as alternatives to cross ventilation in various types of buildings. This involves the development of the advanced passive stack devices, solar induced ventilation, wind-stack driven strategy and even fan induced stack ventilation strategies. nowadays, in the conditions of the warmer climate and denser built environment, the conventional concept of natural cross ventilation does not always successfully apply. therefore, providing effective outlet area at the top of the building and use a stack ventilation strategy to induce vertical air movement.

In Kurdish vernacular architecture size and placement of openings are studied. Exterior openings are small, placed high on the wall, and few in number. This strategy helped the natural ventilation in the rooms during summer by expelling the warm air through the high-level openings and receiving cooler air from the low-level openings [4]. Nevertheless, in vernacular building air flow configurations have to be carefully designed in order to avoid too high or insufficient air flow rate.

Vernacular houses in Erbil use high and low openings to ventilate rooms. This strategy could be improved by placing the high openings at the ceiling level.

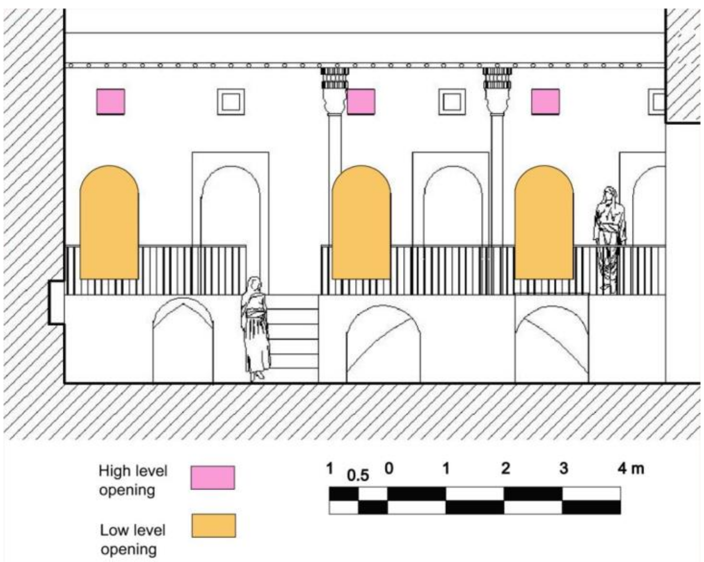


***Fig.6*** *shows a cross-section of vernacular houses in Erbil. The pink shaded areas are ventilation openings located high on the walls of both floors. The yellow shaded areas are low-level ventilation openings [4].*

### 3.2 A wind catcher:

The wind tower found in vernacular houses helps direct air into the house, Wind towers are used throughout the Middle East to cool homes by utilizing the ever-present high winds. Usually the towers are square and constructed with crossed longitudinal partitions dividing the tower chamber into four equal parts that allow the hot air out of the house through the rear division while channeling fresh air into the house [4] The void channel leads the air to the ground, where it passes through humid underground tunnels, resulting in cool air flowing into the rooms [3] Wind tower operates in two different physical mechanisms: First is the function according to the principle of traction of opening facing the wind and the suction of openings back against the wind (Fig. 7). In fact, a wind catcher takes the fresh air into the building and sends the hot and polluted air out.

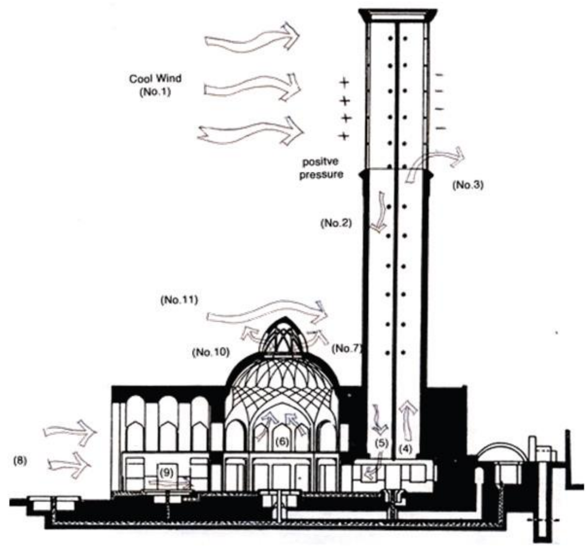


***Fig.7*** *function according to the principle of traction [6]*

Second is the function according to temperature difference During the day, when the sun hits on the air is taken above through the inner air of the entrance [1] southern face of the wind catcher, the air heats in the southern shaft of the wind catcher, and goes up (Fig.7) The wind tower's opening should be directed toward the predominant wind direction. During the night outside temperature becomes cold, and the cold air moves down through the wind tower [1].

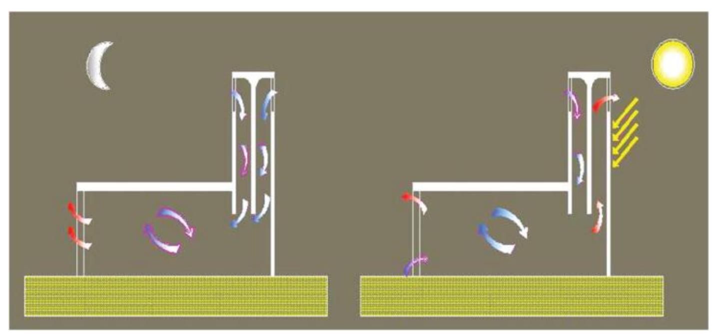

***Fig.7*** *Function according to the temperature difference during the day and the night [6].*

***Fig.8.*** *An aerial view of wind towers in Yazd, Iran [4].*

***Fig.9*** *shows wind tower in Yazd, Iran https://www.sciencesource.com/archive/Wind-Towers-Yazd--Iran*

### 3.3. Water Pool and Fountains:

fountain is a significant component which purify and moisturize the air additionally to improve visually and aesthetic aspects in general it is located in the middle of the courtyard. In the traditional house the spaces are divided depending on the season. it can be seen that the summer spaces for rest is in the south of courtyard oriented toward the north to prevent sun heat as much as possible or on the lower floor whereas winter spaces located in the north of courtyard to take advantage of southern orientation [3]. In addition, some times to support cooling a fountain have been placed in the middle of the Ewan.

## 4. Application of traditional solution of natural ventilation integrated with the technology:

Combining vernacular design strategies with contemporary needs can not only improve the aesthetics, identity, social, structural, and environmental performance of Kurdish cities, it can renew Kurdistan's vitality and unity by linking its ancient architectural past with its promise for the future. Therefore, it is not a coincidence if the shape of the buildings which use a natural ventilation system is usually characterized by tower and chimneys: in deed they are the "path" for the air flows and the same time the architectural device to exploit these physical effects. In this part trying to show some passive cooling strategies that by integrating them with buildings can improve the passive cooling in vernacular design strategies especially in hot dry climate.

### 4.1 Advanced stack ventilation strategies:

**4.1.1. Improving the effect of the stack ventilation for cooling by using solar chimney:** it can use in a hot climate with having high solar radiation and consists of a glazed channel with a black painted chimney and is put at the top of the building. When the chimney is heated by solar radiation it helps increasing natural stack effect which is driven by the difference between the inside and outdoor air temperature with having an opening space at the high and another low opening [7]. It is explained that the solar chimney which relies upon the solar radiation and heat absorption to induce a bigger pressure difference between the inlet and the outlet of the element to increase the stack effect succeeded to generate ventilation rates of between 8 and 15 ACH and had induced air movement of about 0.04m/s at occupied level [8].

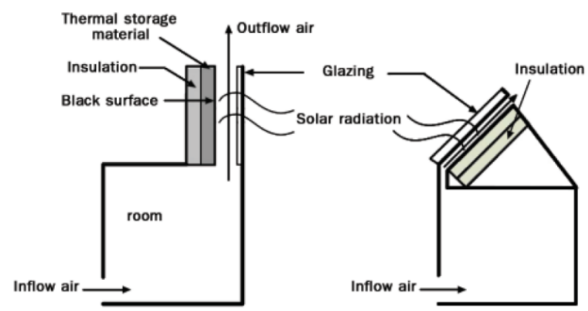


***Fig.10*** *Solar chimney configurations [7]*

it is possible to increase the air velocity and consequently decrease its pressure, draws more air Therefore, it is not a coincidence if the shape of the buildings which use a natural ventilation system is usually characterized by tower and chimneys: indeed, they are the "path" for the air flows and the same time the architectural device for achievement these physical effects [9].

### 4.1.2 Forced ventilation

For a modern building especially the assistance of active or forced ventilation is considered to be the best reliable mean to overcome the inadequacy of natural stack ventilation to effectively ventilate the building. Some time it is necessary to resort to the forced ventilation to ensure good air flow rates. Which needs a system with a little mechanical help might be still considered passive: it depends on how small is the amount of energy utilized to run the engines [10]. The operation of this system and the air velocity that is distributed can be measured. ASHRAE [11] showed that forced ventilation as "intentional movement of air into and out of a building by using fans and intake exhaust vents" are possible alternatives for enhancing natural ventilation especially in the cases when stack ventilation is limited by low room height, too small areas available for high outlets. It is also explained if a house is tight and has an outdoor air flow rate of less than 0.35 ACH, a mechanical supply and exhaust air system is recommended [11].

**4.1.3. Fan Induced Stack Ventilation:** In an effort to make stack ventilation more significant, some advanced stack ventilation strategies that maximize the natural energy sources available from both the sun and wind has been developed [10]. Generally, there are two main basic types of fan induced stack ventilation that have been used to reduce air conditioning cost in the building such as whole-house fan (Figure 11(a)) and attic extractor fan (Figure 11(b)).

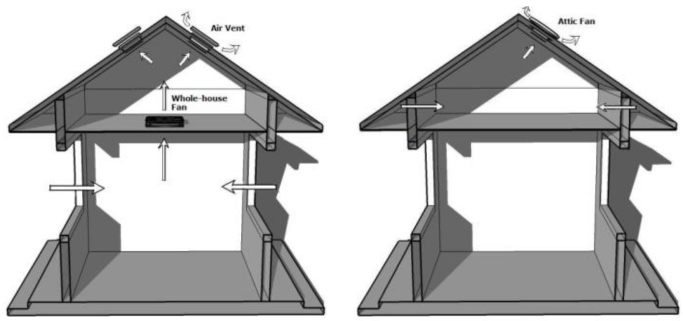


**Fig. 11(a)** whole-house fan [10] **Fig.11(b)** attic extractor fan [10]

### 4.2 Advanced wind tower:

To increase the amount of air flow through the building few small fans can be added to traditional wind catchers to enhance ventilation within the building (Fig 12).

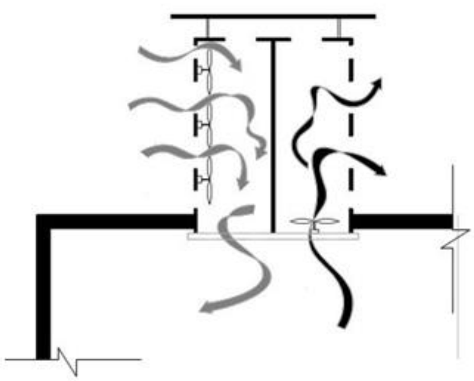

***Fig.12*** *Adding fan to the traditional wind tower [1]*

The wind tower can be modified to include vent control panels that are controlled by a handle, which can change direction to trap the wind or be closed when not needed. Furthermore, by adding filtration at the top for dust Fig.13. Also a manual handle that controls the room ventilation can be added [4].

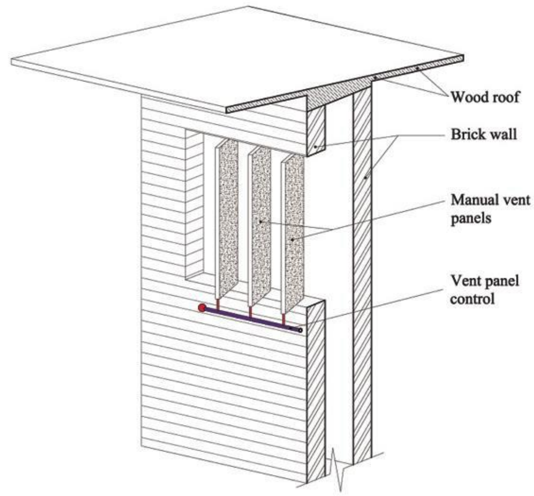


***Fig.13*** *A modified wind tower with moveable vent panels and handle [4].*

### 4.3 Solar-Powered Stack Ventilators

Some innovative such as solar-powered stack ventilators devices which uses both wind and solar energy to operate like solar-powered wind catcher and solar-powered turbine ventilator it can be used in the low wind velocity region to enhance the performance of the stack ventilation strategy [10].

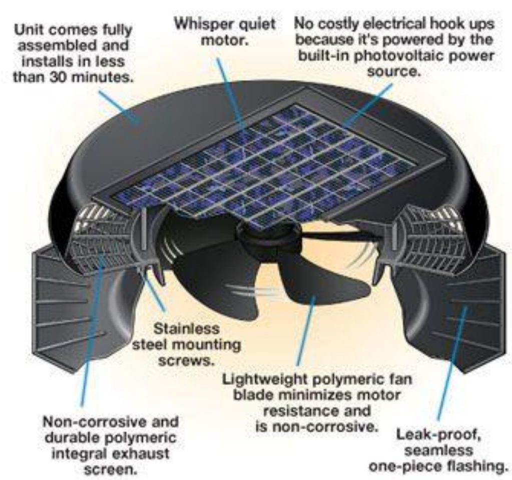


***Fig.14*** *Solar-Powered Stack Ventilators 10-watt solar powered attic fan (Solar Star) from (solatube, Inc.).*

## 5. Vernacular ventilation strategies in modern building:

In the modern buildings various examples can be seen about adding some devices for improving the effect of the natural ventilation.

**5.1. The Inland Revenue Building in Nottingham**: many green strategies are applied in this buildings whose purposes are to increase the natural ventilation because the edge towers not only contain the staircases, but they are also exploited for ventilation. The main strategies are the maximization of daylight and engineered natural ventilation and improving stack ventilation by using thermal towers because Fresh air is drawn through underfloor duct and grill which can be mechanically induced. At the same time warm air exhaust through the door, connected to the stair tower. Moreover, Solar gain in the tower increases thermal buoyancy; warm air is drawn up through the tower by stack effect with having operable tower roof moves up and down to control the rate of air flow and on the top floor, warm air is exhausted at the roof ridge [12].

***Fig.15*** *The Inland Revenue Building in Nottingham, designed by Michael Hopkins and partners [12].*

**5.2. The Bed ZED , Beddington zero energy development in London** : designed by Bill Dunster. It is the UK's largest eco- village the wind cowl ventilation system illustrates the application of energy-grading. Conventionally, much high-grade fan and pump electricity is consumed to deliver low-grade energy for room comfort temperature control and ventilation. This tends to be significant because these systems run for extended operating periods [13].

***Fig.16*** *The Bed ZED development [13]*

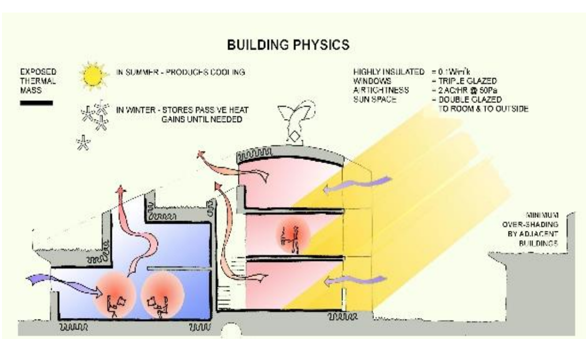


***Fig.17*** *The BedZED by Bill Dunster and its chimneys for ventilation. Source http://twinnsustainabilityinnovation.com*

**5.3 Lycée Charles de Gaulle School in Damascus, Syria**: is an effective example for using natural ventilation strategy in modern building can be seen in Damascus that has a hot -arid climate and summers are dry and hot with less humidity. The project relates to natural lighting, natural ventilation and sun control. The systems are developed and the important point is that the architects indicated that deciding to erect a building in the Middle East without air conditioning. Natural ventilation system of the classrooms is achieved by using courtyard that shaded by trees and advanced solar chimney for increasing air movement [14].

***Fig.18*** *Lycée Charles de Gaulle School [14]*

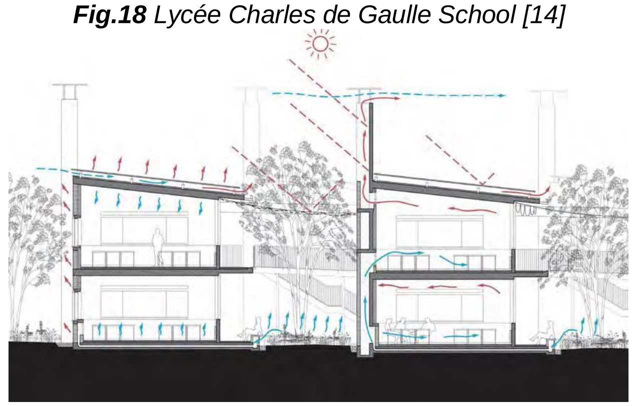

***Fig.19*** *The section of the Lycée Charles de Gaulle School shows natural ventilation system [14]*

**5.4 Modern wind tower in Masdar city-Abu dhabi**: Many passive design strategies that were inspired by the traditional designs in the region can be seen in the design of the Masdar city to provide the highest quality of life with the lowest environmental impacts, in part to demonstrate that environmentally responsible living does not imply hardship. Moreover, the design has an enhanced microclimate through shade, material selection for thermal mass, wind movement and evaporative cooling from water features and the wind tower. Redesign of traditional wind tower that brings cooling breezes to courtyard is modern interpretation of one of the region's most iconic traditional architectural features contemporary. Its designers claim that their designs are rooted in the tradition of walled Medinas. The height of the wind tower is 45m height that means it can capture the cooler upper-level winds and direct them to the open-air public square at its base. Sensors at the top of the steel structure will operate high-level louvers to open in the direction of prevailing winds and to close in other directions to divert wind down the tower [15].

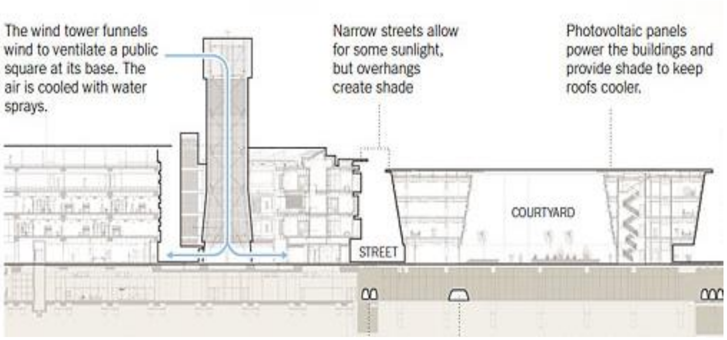


***Fig.20*** *The wind tower, Narrow streets and phoyovoltaic panels [15]*

***Fig. 21. (a)*** *Old wind tower of Dubai;* ***(b)*** *Masdar modern wind tower [15].*

## Conclusion:

From analyzing the vernacular passive cooling strategies in Kurdistan it is realized that the most effective strategy to be adopted in order to control the indoor comfort is the natural ventilation. Moreover, the paper pointed out the simple strategies that can be impressively improving contemporary buildings of hot climate. A proper design of the court yard combined with a correct design of the solar chimney is one of the method can lead to an effective natural stack ventilation strategy. There are some strategies that have a strong chance of being incorporated into the contemporary architecture in Kurdistan such as, fan Induced Stack Ventilation, its effectiveness increases with the assistance of active or forced ventilation and considered to be the best reliable mean to overcome the inadequacy of natural stack ventilation alone to successfully ventilate the building. In addition, Solar-Powered Stack Ventilators may be considered as a possible alternative to operate like solar-powered wind catcher and solar-powered turbine ventilator which uses both wind and solar energy to enhance the performance of the stack ventilation strategy. The analysis of the Modern passive buildings highlights that sustainable design systems that are derived from vernacular architecture can be adapted to the contemporary architecture in Kurdistan and redesigning these systems with sustainable principles and using new technology are some effective solutions for strategies that can struggle with harsh climate of hot regions such as wind tower.

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