Journal of Fundamental and Applied Sciences

Research Article

ISSN 1112-9867

Available online at http://www.jfas.info

USERS PERCEPTION OF A WIND TOWER FOR PASSIVE COOLING IN HOT DRY AREA OF SOUTHERN ALGERIA: A CASE OF OULED DJELLAL BISKRA

A. Torkia[1*], S. Mazouz[2], A. Djouima[3]

[1]Faculty of Sciences and Technology, Institute of Architecture, University of Biskra, Algeria

[2]Faculty of Earth Sciences and Architecture, University of Oum El Bouaghi, Algeria

[3]Institute of Architecture and Urbanism, University of Batna I, Algeria

Received: 17 March 2018 / Accepted: 31 August 2018 / Published online: 01 September 2018

ABSTRACT

This paper is a synopsis of the results of a socio-cultural research on the wind tower as a sustainable cooling system, introduced in hot dry areas of southern Algeria. This element is integrated into 80 dwellings neighbourhood in Ouled Djellal. The wind towers were closed or removed by users despite their proven thermal performance by the authors [1]. This paper reveals the causes behind this rejection and users' perception issues using in situ observation, interviews and survey. It unveiled that wind towers are useful, successful and are to be incorporated into new residential buildings' designs only if incompatibility errors between design, implementation, use, and control system are avoided. The survey proved, the cultural acceptance of this new element in Algeria by the population surveyed of low to medium social class (56.82% yes and yes under conditions, of which 38.64% yes without conditions).

Keywords: Wind tower**,** perceptions, passive cooling, hot and semi-arid climate, sphinxplus2

Author Correspondence, e-mail: torkiaessil@yahoo.fr

doi: http://dx.doi.org/10.4314/jfas.v10i3.32

1. INTRODUCTION

Passive cooling is an old concept and a very significant stake as well in economic terms for the different operators of the air conditioning domain, as well as thermal convenience in terms

of occupants' comfort. In hot dry climate, the choice of wind towers represents the solution to the cooling problem in traditional vernacular architecture. The wind tower is a tall chimney with openings towards the prevailing favourable wind (Montazeri & Azizian) [2], consists of a head, a brick column with internal shafts, and the room under the tower. Its main purpose is to capture air from above and transmit it indoors, and therefore providing the space with fresh air using the natural flow of wind (J. Khodakarami & M. R Aboseba) [3]. The wind catcher is a functional construction component that contributes to preserving our health by decreasing the intense use of active ventilation. As a result, it reduces the high demands of energy and the emission of CO2 (S. Mahsa & S. Melika Ghamkhar) [4].

Currently, in Algeria, there were few attempts to analyse the technology of the wind tower realized by the Egyptian design studio "El Menyaoui brothers" in 1980 in Ouargla and Ouled Djellal (Southern cities in Algeria characterized by a hot and dry climate), to explain their advantages and disadvantages in order to identify the real causes of the rejection of this bioclimatic system in these areas Figure 1. In this domain, all researches are limited to evaluating the potential liabilities involving numerical simulation and experiment (academic's perception). In order to get more holistic understanding, the opinions of users were taken into consideration (user´s perception) in this study.

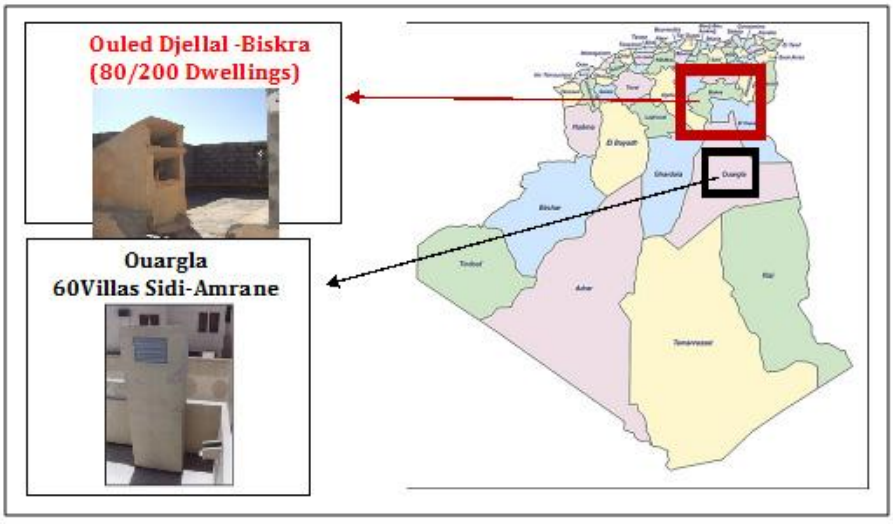

Fig.1. Sites of the wind tower in habitat (Egyptian design studio) in southern Algeria

2. PREVIOUS KNOWLEDGE

Though most researches were about climatic and technical features of the wind tower, only a

few studies have treated its thermal performance linked to social and cultural aspects. In 2007, Rosa Schiano-Phan & Brian Ford [5] both did research and applications of Passive and Hybrid Downdraught Cooling (cooling towers), adjusted in four non-residential buildings in the South West of the United States (California, Arizona, and Utah). Occupant perceptions of internal conditions, actual energy requirements and efficiency were associated in their work. The Post Occupancy assessment about wind towers incorporated with misting devices or cellulose mats for cooling system where treated by a survey, including questions on: thermal comfort (summer and winter), air quality, lighting, noise, design, need, perceived health, productivity and image to visitors. The results revealed that occupants have a better perception of the building when they have a degree of control over its operation and are aware of the design intention and the control strategy. It also showed us that other factors matter; such as local culture, context and the nature of occupants' work (environmental domain) contribute to the success of this dispositive. Among the studies realized in Iran, there is the work of Ahmadreza and Fergus Nicol [6] which has provided a method for research focusing on vernacular passive-cooling strategies. This method was conducted in two steps. Step one was evaluating the existing passive-cooling strategies through three aspects: cultural acceptance, thermal comfort of occupants and energy performance. Step two was classifying modern building types by their construction and form and evaluating their energy performance numerically. The results of the research developed some recommendations for applying vernacular architectural strategies to existing modern buildings; such as meeting the applicability, compatibility and actual requirements of people. In 2012, Ahmadreza Foruzanmehr [7] investigated the factors affecting the success/failure of this vernacular strategy in traditional dwellings in the city of Yazd, Iran, the positive and negative attributes of this system were identified by using a survey. The negative aspect most cited by users is the intrusion of dust and insects, cost, and its inapplicable nature to new buildings with low space efficiency. The diversity of positive factors (aesthetic, economic and thermal comfort) confirmed that wind catchers have been constructed to serve various requirements, not only to provide ventilation and thermal comfort. Gianluca cadoni [8] developed some rules to help the architects that want to integrate passive cooling systems in building and evaluated its impact on architectural design.

The difficulties in using a traditional cooling system (wind tower) and the opportunities they could offer to today's architecture have not been addressed in Algeria. Most of the studies carried out in this field were focused on the system itself, thus ignoring its impact on the space where it is integrated, and its cultural acceptance. Only three studies limited to thermal performance were carried out on wind towers in Algeria. Bouchahm in 2011 [9], confirmed the thermal efficiency of this system realized in individual housing (case of 60 villas Sidi Amrane, Ouargla). Knowing that this device has been closed off (or shut off). The maximum temperature variation obtained between outside (air inlet) and inside (air outlet) was 6°C by humidifying the duct. An optimization of the system was proposed later and validated numerically. The maximum simulated gap was 18°C. Y. Bouchahm in 2008 [10] and A. Djouima et al in 2018 [11], constructed the prototype of Y. Bouchahm to cool an office of 45.36 m^2 and 2,7 m height in Hassi Messaoud (town in southern Algeria). The investigation in situ confirmed the results of Y. Bouchahm, but also exceeded expectations in terms of temperature and average relative humidity output (22°C/46,26%). In 2014, after opening of the air inlets of one of the wind towers shut off by the residents of the 80/200 bioclimatic dwellings in Ouled Djellal, S. Mazouz and A. Torkia [1] validated the thermal performance of this device. The results were very encouraging and they confirmed the advantage of the application of this dispositive in hot dry climate. The maximal variation of temperature obtained at 04pm at the air inlet was 12,4°C in the ground floor and 11,5°C on the first floor. The drop of temperature obtained at the room equipped with wind towers (Wasteddar) was 13°C in the ground floor and 10,2°C on the first floor. The results of experimental studies conducted in Ouargla and Ouled Djellal validated the thermal efficiency of this passive system in southern Algeria but the wind towers are still closed. The failure of these two experiments is probably due to other factors besides the thermal factor. The failure parameters are to be determined in order to lead to the generalization of its exploitation in this region.

3. METHODOLOGY DESCRIPTION

The research has been structured into two main steps. The first step consists of a description and identification of the case study; the second is devoted to the application of the adopted research techniques.

4. SITE AND DWELLINGS DESCRIPTIONS

The study is carried out in the town of Ouled Djellal-Biskra, which is located in the southern area of Algeria (34°25´N 05°4E), characterized by semi-arid climate; very hot and dry in summer and cold in winter. The temperature diurnal variation is important [1]. The 80 bioclimatic social dwellings neighbourhood was selected and analysed as a case study Figure 2. Its built fabric structure is compact with regular parcels (square or rectangle shape) in a way to diminish the area exposed to the sun. Each parcel is characterized by a group of adjoining and superimposed dwellings, composed of 04 apartments on the ground floor and 04 upstairs. The type of dwellings has an intermediate urban form (between the individual house and the apartment building) with individualized access to housing and private outdoor spaces for each dwelling (courtyard and garden). These properties offered a degree of intimacy and an interesting alternative to traditional housing.

Fig.2. The site of the case study

The types of housing vary from F2 to F5, thus allowing several possibilities of assembly Figure 3. The connection between the assembling units is carried out via covered passageways integrated into the volume composition of the groups in order to protect themselves against the vagaries of the climate, in particular the intense radiation of the summer and the sand storms. Regardless of the type of housing (F2, F3, F4 or F5), its spatial organization follows the same pattern of principle that is linked to the lifestyle of these inhabitants, social practices and their low revenues.

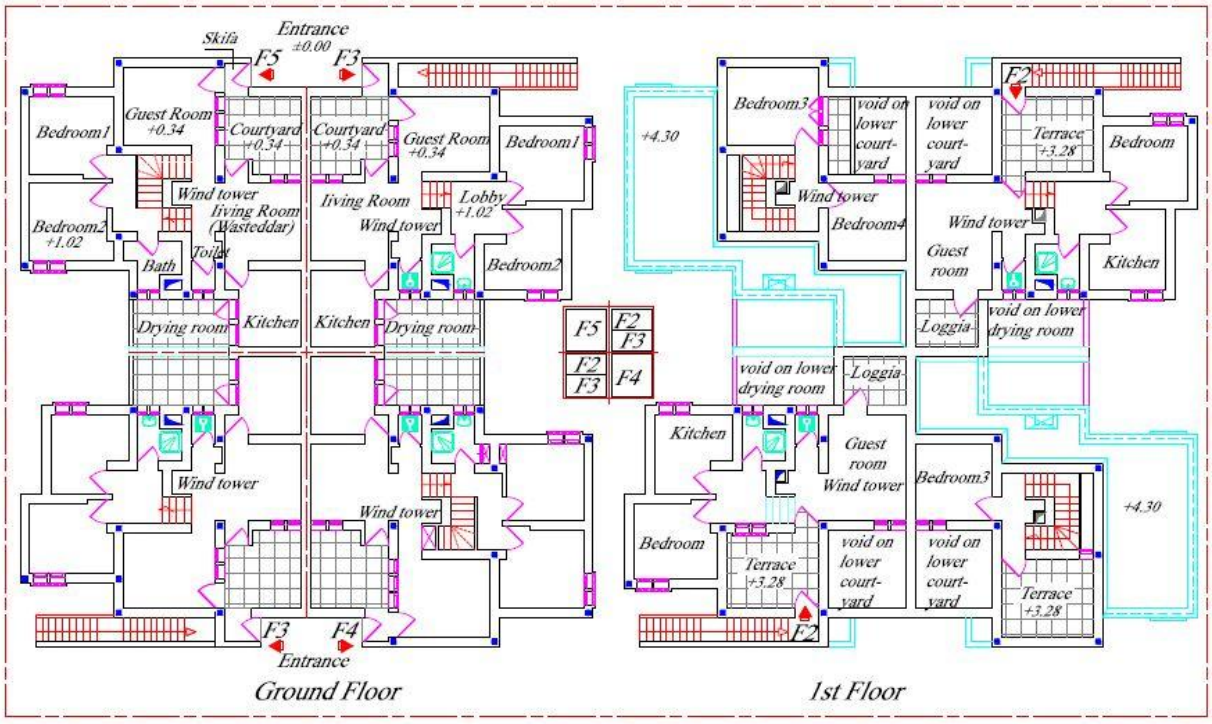

Fig.3. The ground and first floor plans of assembly units

At the entrance, there are two filter spaces presented by a skifa (open and covered area) and the courtyard that leads directly to dar Dhiaf (guest room) and to the secondary access of the private household. By accessing this last private part, all rooms are organized around wast dar (living room) the central core of the house where the wind tower is located to ensure passive cooling Figure 3. The day space is distinguished from the night space by a 0.68m level difference. The kitchen, bathroom and toilet have a direct access to a loggia which can be used as a functional space annexed to the kitchen.

4.1. Surfaces by Spaces

The surfaces by spaces as well as by type of housing of the case study are given in the Table 1. below, as well as the surfaces recommended by the Algerian and French standards. The comparison of the case study dwelling typical surface to the technical and functional requirements designated by the Algerian Ministry of Housing and Urban Planning applicable to social housing 2007 [12], Algerian Official Journal n°6 [13], the French code of construction and housing (CCH) [14] and the French law of SRU n° 2000-1208 [15], illustrated that most of spaces are lower than Algerian or French standards recommended. Also, it was noticed the total absence of storage space.

Table 1. Comparison between dwelling area type and the recommended Algerian/French norm

Space	**Area by type of dwelling in (m^2)**				**Algerian Standard**	**French Standard**
	F2	**F3**	**F4**	**F5**		
Guest room	-	11,80	11,80	11,80	Between 19-21	9,00
Lobby as living room (wasteddar)	17,70	14,20	14,20	14,20	7,00	-
Bedroom 1	10,55	10,65	10,65	10,65	between 11- 13	12,00
Bedroom 2	-	9,30	9,30	9,30	between 11-13	12,00
Bedroom 3	-	-	10,24	11,80	between 11-13	12,00
Bedroom 4	-	-	-	10,24	between 11-13	12,00
Kitchen	9,70	8,80	8,80	8,80	10,00	8,00
Bathroom	2,90	2,90	2,90	2,90	3,50	3,00
Toilet	1,20	1,20	1,20	1,20	1,00	1,00
Courtyard (ground floor) / Terrace (1^{st} floor)	11,80 (width= 3,10m)	11,10 (width= 3,20m)	11,10 (width= 3,20m	11,10 (width= 3,20m	-	¼ of habitable area
Loggia width = W	5,20 W= 2m	8,00 W= 2m	8,00 W= 2m	8,00 W= 2m	Width≥1,40m	-
Storage (except storage kitchen)	None	None	None	None	between 1 and $2m^2$	0,3% of housing size
Circulation lobby and corridor	5,00	5,00	7,50	7,50	12% of habitable area	-
Habitable area Of dwelling (m^2)	**47,05**	**63,85**	**76,59**	**88,39**	**49,5≤F2≤52,5 67,9≤F3≤72,1 79,5≤F4≤84,5 93,1≤F5≤ 98,9**	**54≤F2≤60 66≤F3≤73 79≤F4≤88 89≤F5≤ 99**

The inhabitable area of all analyzed types (column in red Figure 4) is less than the surfaces

norms. The apartments are tiny and without storage space, which obliged the residents to make changes in order to gain surface.

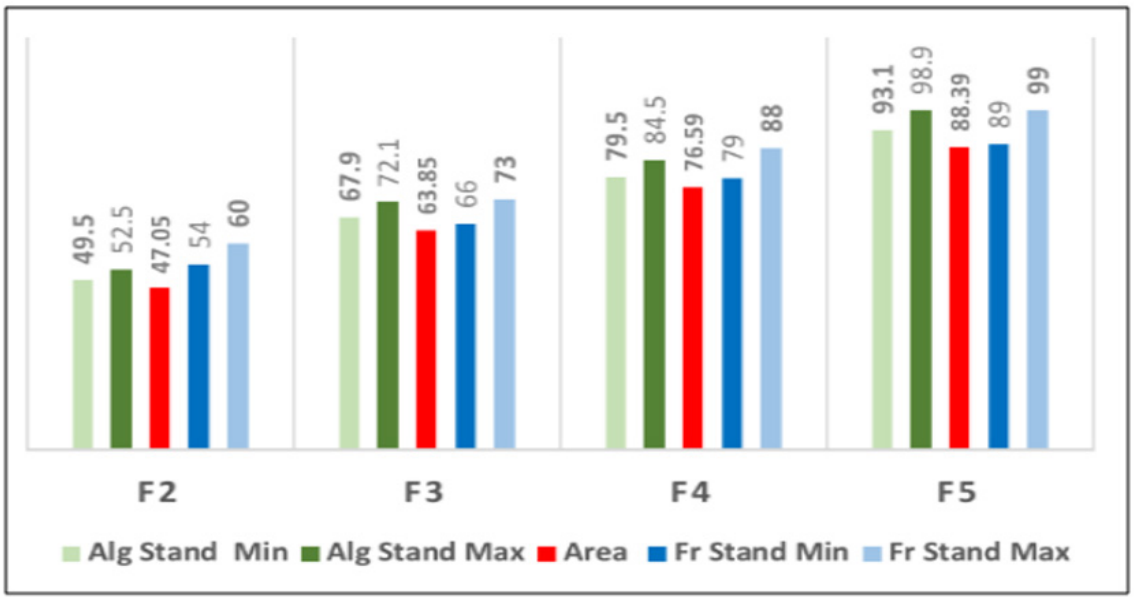

Fig.4. Comparison between inhabitable area dwelling type to the recommended Algerian & French norm

4.2. Wind catcher description

In addition to the thick stone walls with great thermal inertia (40cm of width), and the diminution of the surface of openings (60x140cm^2), the wind tower was used as a bioclimatic solution ensuring living space's passive cooling of the two apartments superimposed by two effects: wind effect and buoyancy driven flow. The wind tower is divided into two ducts serving the ground and the 1st floor with an aperture outlet air section of 0,18m^2. The head of the tower consists of two air inlet openings without protective grid. The first one with a section of 0.25m^2 serving the ground floor and the second has a 0.28 m^2 serving the upstairs Figure 5.

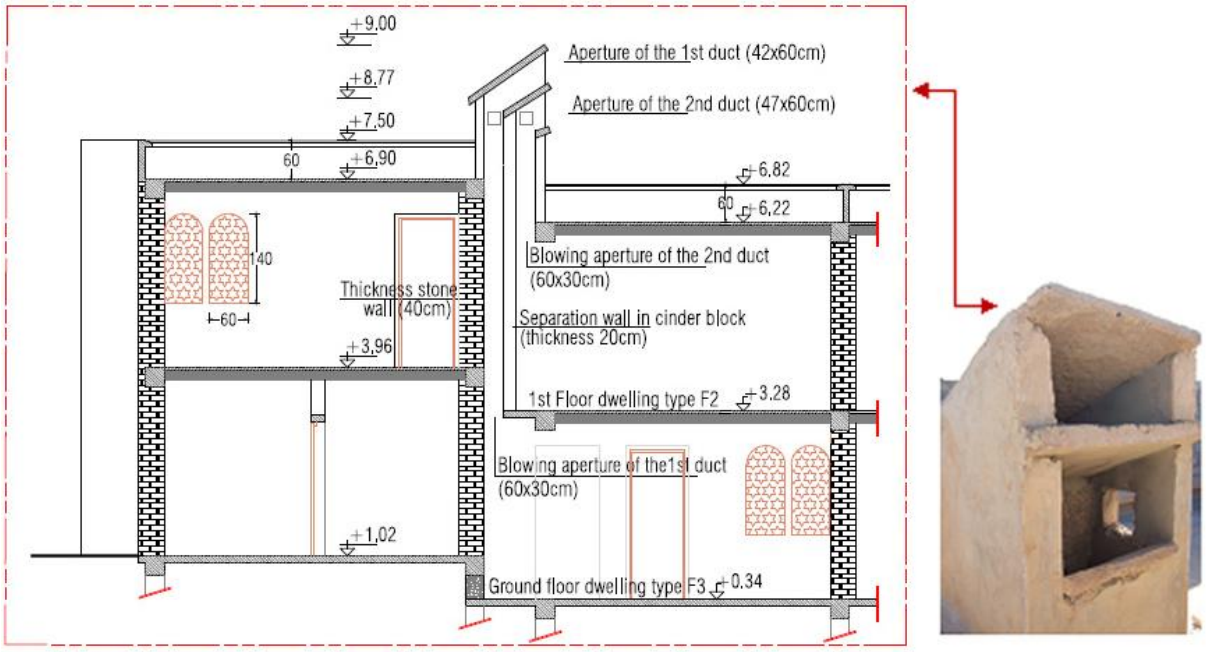

Fig.5. Wind catcher in the case study dwelling

5. ADOPTED RESEARCH TECHNIQUES

Three techniques of investigation were adopted to reveal the perception's question of this system in terms of comfort, convenience, economy, aesthetic and cultural acceptance (qualitative assessment) which are: direct observations in situ, semi-structured interviews and sociocultural survey. The results of the survey were processed by the software "Sphinx Plus2".

5.1. First Technique: In-situ non-participatory observation

The closing off and transformation aspects observed outside or inside the dwellings by direct observation of wind towers are illustrated and commented on Figure 6:

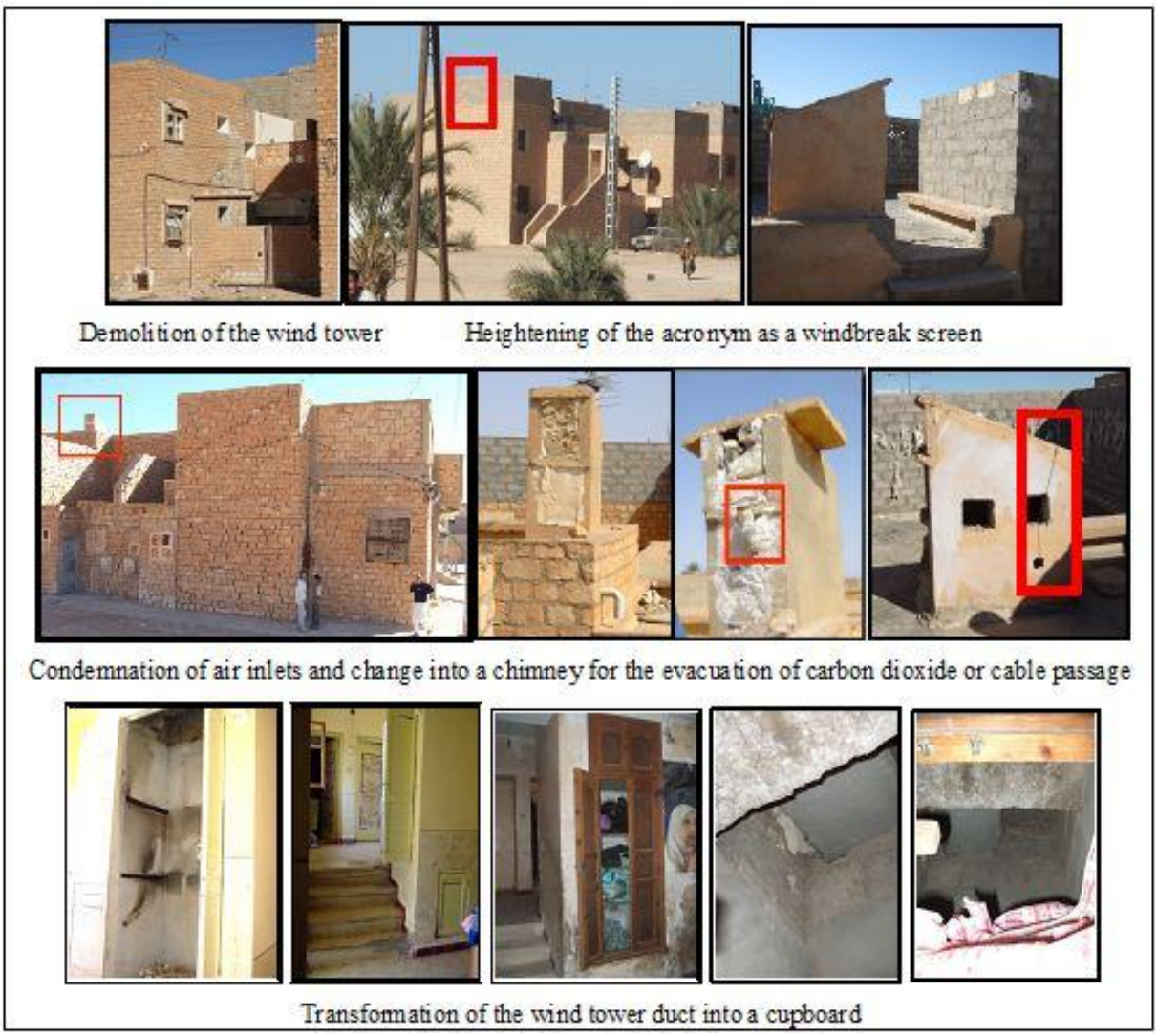

Fig.6. Observed aspects of rejection of the wind tower

5.1.1. Discussion and Limits of the First Technique

On-site visits and in-situ photos, confirmed the rejection of the wind tower by locals. The aforementioned rejection is observed from the outside by: the disappearance of the wind tower at the level of the facade (demolished or hidden behind the important elevation of the acroter realized by the inhabitant for security reasons (theft) or privacy, or by the closing air inlets and transforming the system into a chimney for the evacuation of carbon gases or as a cable passage. The refusal of the wind tower was also established by visiting the interior of some dwellings. The column of this system has been transformed into a wall cupboard for lack of storage space or to a chimney for heating during winter time.

The results of the direct in-situ observation in situ allowed to collect information real time on

the different modes of use and non-use of the wind tower in the studied case, by mentioning the forms of condemnation and transformation that repeat themselves in a remarkable way. However, this technique does not allow the collection of all the data necessary for the analysis, because of two reasons: The first is relative to the field of vision which is restricted, even by changing the place each time; it does not allow the sweep of the whole extent of the considered site. As a result, some modification or transformation could not be observed and raised. The second is imperative, it concerns the user's and the local authorities' perception and the region's scarce knowledge towards the wind tower.

5.2. Second Technique: the interview

The purpose of the interview was to ask the interviewees in a semi-direct way on the case study's history and to make a qualitative assessment on the rejection of the wind tower system by the authorities during this time, knowing that: out of a program of 200 bioclimatic social housing units, only 80 dwellings were built with wind towers, the rest was done in a conventional way in front of the studied case Figure 7.

Fig.7. Views on the rest of dwellings realized in a conventional system without wind tower

The interview technique was established with users and local authorities of the SUCH (subdivision of Urbanism, Construction and Housing) including the heads of departments who attended the different steps of the project from design to realization.

5.2.1. Discussion and Limits of the Second Technique

Through interviews with users and local authorities, it has been found that the rejection of realization of bioclimatic dwellings with wind towers was due to several parameters. A few of which are: The local authorities' ignorance of the utility of the system, the expensive cost of

the project realized with stone bricks, and its long lead times of implementation. The state's concession of apartments in 1994 to the benefit of the tenants encouraged them to make changes on their housing particularly on the wind tower. The first modifications made on this cooling element were the suppression of its humidification system by the responsible authorities and the closing of the air inlet in winter by the inhabitants afterwards. The wind tower was shut off by the inhabitants on the pretext of protecting themselves against the access of rain in winter, the amplified noise of wind, as well as for security reasons (theft). The wind tower -compared with the other current means of ventilation and cooling has very limited time efficiency and a rather unfavourable impact on the rate of ventilation provided.

Despite the advantages that the interview offers such as flexibility and subjectivity due to the direct contact with the interviewee, the qualitative data collected represent only the opinion of a very limited number and not the entire considered population. The lack of comparability of interviews and the need for an application to a larger number in order to know the perception of each household on the wind tower about its convenience and its assessments, made the exploitation of a survey imperative.

5.3. Third Technique: socio cultural Survey questionnaire

To perform a qualitative socio-cultural survey, self-completion questionnaires were administered in the summer of 2017 to the respondents' home and completed by the population itself. Considering the limited size of 80 dwellings neighbourhood, the total number of apartments was taken as a sample. The questionnaire form was developed and processed using the Sphinx Plus2 software. It was written in a simple and easily understandable vocabulary; in both languages: French and Arabic. The survey was undertaken during the course of one day using a three-page format. Its structure was based as follows: An introduction clarifying the nature and purpose of the research and ensuring the strict confidentiality of the respondents’ answers, and four parts of questions. The first part includes some personal information characterizing the sample of the target population, the second is related to the identification of the wind tower as ventilation and cooling system by users, the third part describes the current state of this system and reasons of its rejection, the last part focuses on the level of respondents’ satisfaction with this system and the opinion of the interviewees about its integration into new residential buildings in the hot dry regions of

Algeria.

5.3.1. Distribution, Collection and Counting

80 self-completed questionnaires were supposed to be administered to the residents of 80 bioclimatic housing as a case study. Only 50 were distributed and among these 44 were completed and returned. The calculated theoretical response rate was 55% (50 distributed/ 80 expected to be distributed) which can be considered acceptable, but the effective response rate was 88% (44 rendering/50 really distributed) which can be considered adequately representative. The results of these two rates are due to several factors such as: The transformation of some ground floor dwellings into commercial premises, the temporary closing of some dwellings for rent, some owners' abandonment and eviction of their apartments for immigration, some occupants' absence from their apartments on the day of the survey; and in some cases, the refusal of some housewives to open the door in the absence of their spouses for social and security reasons.

5.3.2. Results and interpretations of the third techniques

Two types of analysis were established: Flat sorting and cross-sorting analysis.

5.3.2.1. Results and interpretations of flat sorting analysis

Flat sorting (uni-varied) analysis consists of the calculation of frequencies modality.

Synthesis of the characteristics of the target population sample (part1),

Table 2 shows that the majority (76%) of the population surveyed are simple civil workers, living in F3 type social housing, married with more than 3 children, of low to medium social class and having a certain level of education (study). Most apartments (88.64%) are still occupied by their original owners or by their children and grandchildren since 1984 to this day. This shows that few occupied dwellings 11.36% in this neighbourhood have often been used for multi-occupancy renting. The narrowness of housing was observed and established through the density of occupation (5 to 7 people as an average and often more in an F3 of 63,95 m2 instead of an F4 or F5). Type F3 is the dominant model, it represents a percentage of 59.09%, type F4 represents 18.18%, type F2 represents 13.64% and type F5 (9.09%) is the least adopted model. This distribution is not appropriate for the number of occupants per dwelling. For social housing, proposing a higher number of F4 type dwellings instead of F3type ones and completely eliminating F2 type ones - not suited to the sociological way of

life of the region- was for the retained solution.

Table 2. The characteristics of the target population sample

80/200 Dwellings Survey			
Variable	**Modality cited first (%)**	**Modality cited in second (%)**	**Modality less cited (%)**
Occupation	Official 76%	Retired 22,73%	Liberal function 11,36%
Level of study	Secondary 31,82%	University 27,27%	Primary 9,09%
Family Situation	Married 86,36%	Single 11,36%	Other 2,27%
Number of Children	Between 3and5 45,45%	More than 5 29,55%	Less than 3 9,09%
Form of ownership	Owner 63,64%	Tenant at the state 25%	Tenant at private 11,36%
Date of occupation	In 1984 52,27%	Other 38,64%	In 1994 9,09%
Type of Dwelling	F3 59,09%	F4 18,18%	F2 13,64%
Level	Ground floor 56,82%	1st floor 40,91%	No answer 2,27%

Synthesis of the identification of the wind tower by the users (part2),

More than half of the users (63,64%) believe this system is a simple ventilation duct which is imported and is intrusive to the region and the country's culture, but they cannot determine its exact origin (50,09%). In addition, they are aware of its usefulness as a natural ventilation device but few have responded that its role was for evaporative cooling or for air renewal Table 3.

Table 3. The identification of the wind tower by the users of 80/200 dwellers neighbourhood

80/200 dwellings Survey			
Variable	**Modality cited 1st(%)**	**Modality cited in 2nd(%)**	**Modality less cited (%)**
System recognition	Yes 63,64%	No 36,36%	-
System identification	Simple air duct 54,55%	No answer 36,36%	Chimney for heating 9,09%
Knowledge of its origin	Yes 40,91%	No answer 36,36%	No 22,73%
Country of origin	No answer 50,09%	Middle East Egypt 29,55%	Local, southern region of Algeria, Iran 9,09%
Opinion on its usefulness	Yes 54,55%	Do not know 34,09%	No 6,82%
Utility	Natural ventilation 58,06%	Chimney 16,13%	Ventilation and evaporative cooling 6,45%

Synthesis of the current state of the system and its causes of conviction (part3),

According to the results indicated in Table 4., 81.82% of the surveyed population sustain the closing of their wind towers, either partially or totally. The very low percentage (15.91%) of respondents whose wind towers have completely open Figure 8. is justified by two reasons: Either that the dwelling is rented where the tenants do not have the right to make any modifications to this sheath, or the lack of awareness of its usefulness by the majority of the household heads; which represents a rate of 27,27% (2nd modality cited from the target sample).

Table 4. The state and the various modifications made to this system

80/200 dwellings Survey			
Variable	**Modality cited 1st (%)**	**Modality cited in 2nd (%)**	**Modality less cited (%)**
State of the system	Totally closed 38,64%	Open to the inlet air 25,00%	Open to the outlet air 18,18%
Causes of opening	No answer 45,45%	By awareness of its usefulness 34,09%	No right to modify 11,36%
column use mode	No answer 50,00%	Natural ventilation 27,27%	Evacuation of gazes 18,18%
Reasons for condemnation	Cold winter air 28,36%	penetration of all impurities27,27%	Transformation in the interior of dwelling20,90%

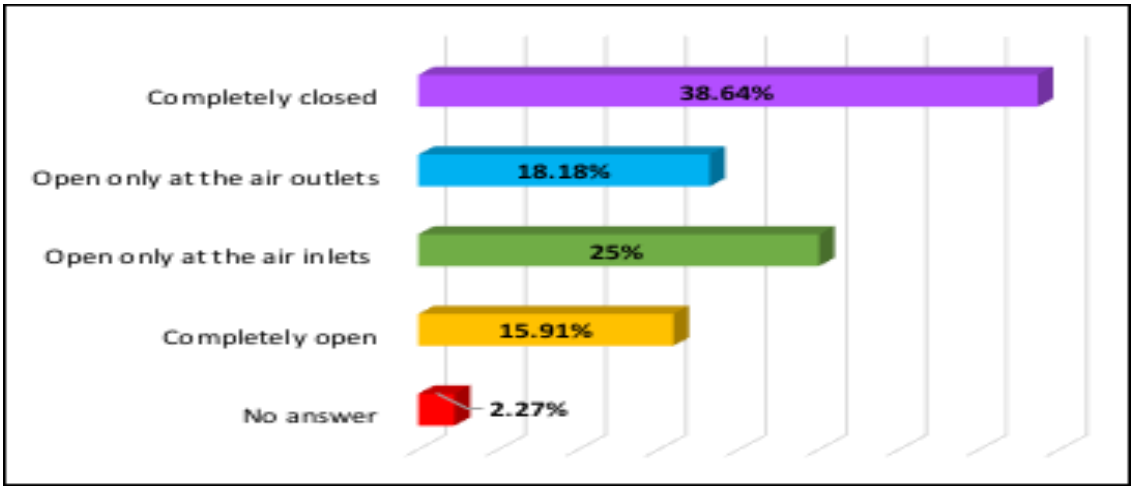

Fig.8. Histogram of the air inlets' and outlets' state of the Ouled djellal wind towers

The causes of the conviction -of which the very close percentages are various Figure 9.- are summarized in two essential points: the inadequate adaptation and the bad implantation of the sheath inside considering the very limited inhabitable area and the tiny social housing.

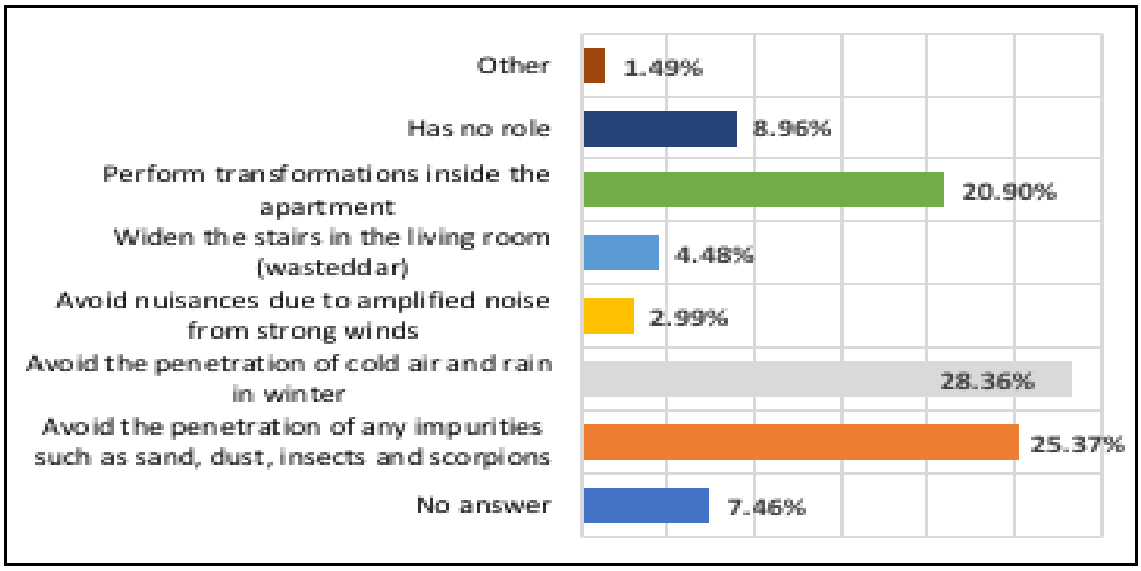

Fig.9. Histogram Reasons of Conviction

Synthesis of the perception and the opinion of the inhabitants on this system (part4).

Regarding the idea of vulgarizing the system in new residential buildings, the percentage of 56.82% Figure 10. representing the appropriate and suitable responses under conditions proves that the system is culturally acceptable Figure 11. provided that it is modernized, and has a controllable head system, a convenient location (that does not interfere with the proper operation inside the space) and is thermally efficient Figure 12. On the other hand, the percentage of 40.38% of the respondents who did not answer was justified by the ignorance of the utility of this system. The results of the observations and interviews confirm the results of the survey.

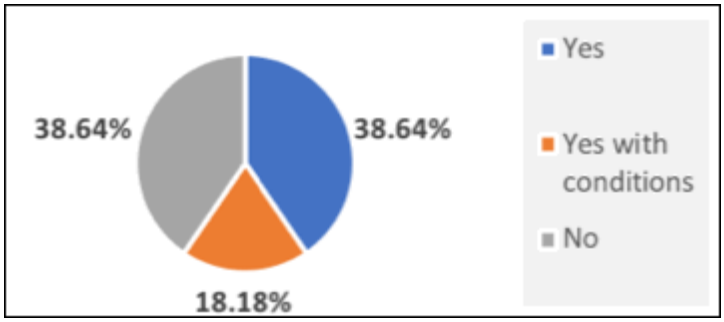

Fig.10. Users opinion sector on the vulgarization of the system in southern Algeria

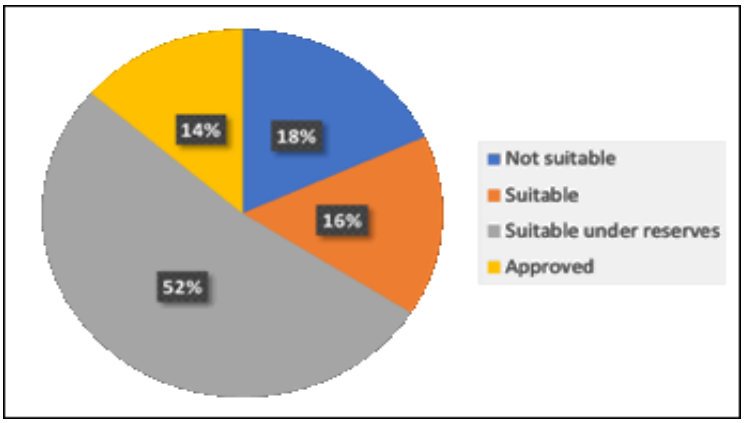

Fig.11. Sector of users' opinions on the suitability of the wind tower system

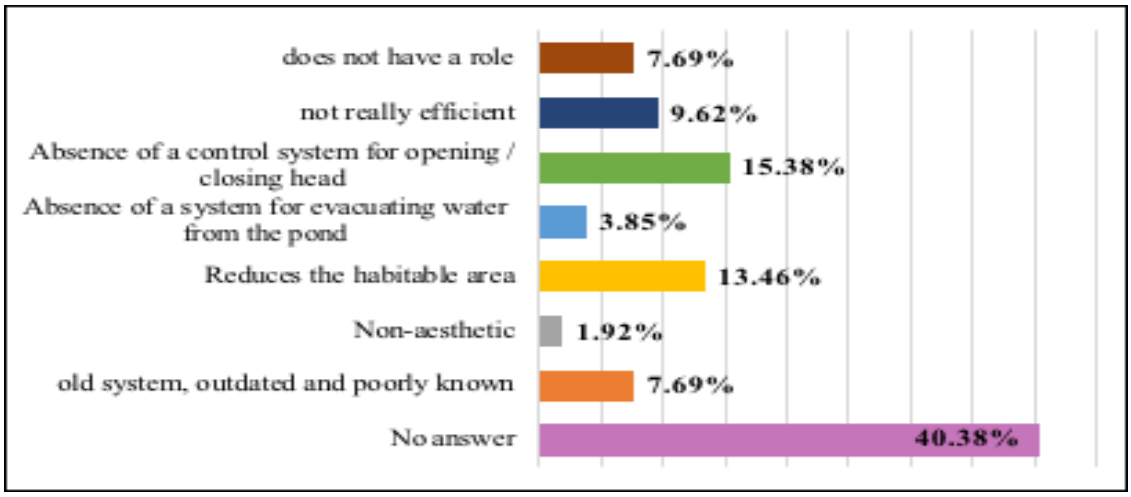

Fig.12. Histogram Reasons of the refusal of the wind tower system (reserves)

5.3.2.2. Results and interpretations of cross sorting analysis

For a deeper understanding, a cross-sorting was established by combining the variables of the 1st axis of the questionnaire representing the properties of the inhabitants with the variables of the 2nd and 3rd axis representing the identification of the wind tower system and its state respectively. Two combinations were analysed: The educational status and the users' knowledge of the wind tower. All in addition to the type of apartment possession, and the state of the wind tower.

The result of the 1st combination, Figure 13. showed the independence of the variable that is the identification of the wind tower system by inhabitants according to their educational status. Respondents, regardless of their level of education, know the wind tower. This knowledge was transmitted between them through communication, the social bonds, and the cohabitation that characterizes the southern society. As the neighbourhood is homogeneous and small, the

information spreads quickly.

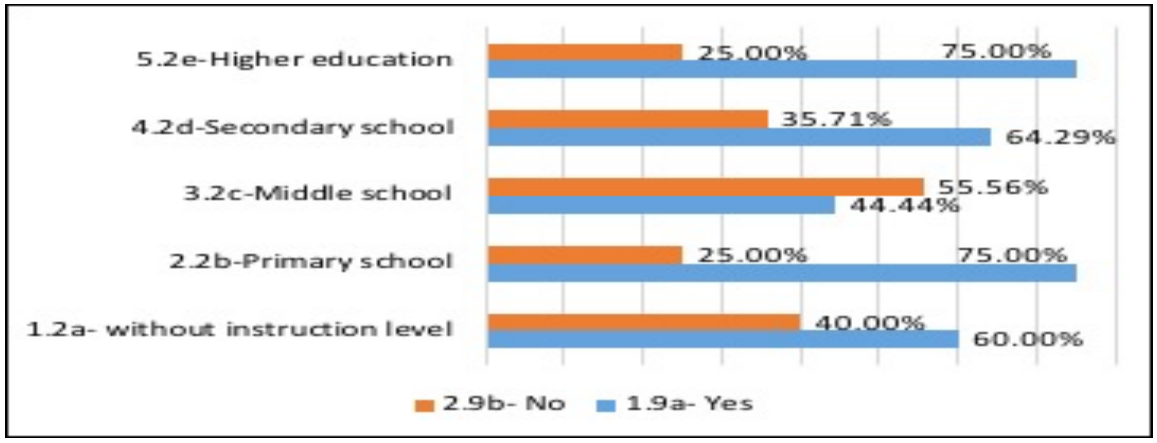

Fig.13. Table and Histogram of cross variables (level of education, knowledge of the system)

The result of the 2nd combination, Figure 14. confirmed the great dependence of the wind tower's state variable with the variable nature of possession housing. The apartments occupied by their owners have undergone a very important rate of transformation compared to those occupied by tenants.

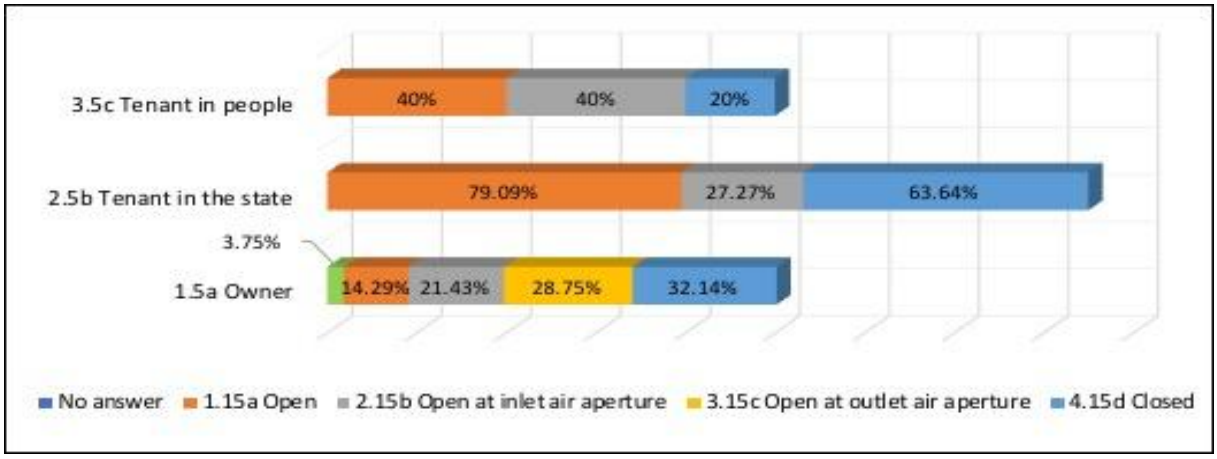

Fig.14. Histogram of cross variables (Type of possession dwelling, State of the wind tower)

5.3.3. Ranking of Positive attributes of wind tower

- Acceptance of use and extension in similar hot Algerian areas (56.82% of comments).
- The wind tower is still appreciated by the population surveyed of low to medium social class. It is suitable, can be adapted and applicable to new residential buildings (52.27% comments but under conditions).
- The inapplicable statement was the least mentioned (18.18% of comments).

5.3.4. Ranking of Negative attributes of wind tower

-Ignorance of the system (40.38% of respondents did not answer)

- Uncontrollable head (15.38%).

-Bad placement in the spatial organization (13.46% of the comments)

- Not of any noticeable performance or use (9.62%).

- The old system, unknown and irrelevant when it comes to representing the day-to-day lifestyle (7.69%)

- Unattractive and non-aesthetic (1.92%)

6. CONCLUSION

The wind tower system in the arid and semi-arid hot climate in southern Algeria has undergone several transformations in individual housing (case of 60 villas of the military neighbourhood in Sidi Amrane) in Ouargla and semi collective (case of 80 social housing) in Ouled Djellal-Biskra. The city of 80 semi-collective social housing units in Ouled Djellal was selected and analysed as a representative study case. In this work, three research techniques were exploited, namely: the open observation in situ, the semi-structured interview and the self-completed questionnaire survey confirmed the rejection of the wind tower by the inhabitants. This rejection has taken several forms and types of which the causes are due to errors of incompatibility between design, use and control systems, administrative and political decisions without prior thorough study, poor implementation or changes. On the other hand, it has been concluded that these problems are more obvious and felt when the distance between decision-maker, architect-designer and users is great. The rejections of the wind tower resulting from this analysis are related to: The limited thermal efficiency compared to the air conditioner, the failure of the architectural design’s development of the wind tower, lack of awareness of the utility of this element as an ingenious, healthy, economical and sustainable passive cooling system. Subsidized energy costs in the Saharan areas have favoured and encouraged the use of air conditioning to the detriment of passive cooling solutions. All these constraints have hindered the use of this system by users and therefore its popularization with local authorities.

These results confirm the previous studies of Ahmadreza and Fergus [5], Ahmadreza

Foruzanmehr [6] and Gianluca Cadoni [8].

The program of housing with wind towers proposed by the El Menyaoui Egyptian design studio, did not comply with Algerian regulations in terms of inhabitable surface. Despite the appropriate spatial organization, the type of housing proposed (especially type F2 and F3) does not correspond to the sociological way of life of the region. The poor distribution of the number of dwellings by type F3, F4 and F5 has magnified the problem. All of these factors have made this experience unique and abandoned, despite the bioclimatic benefits it offers.

7. ACKNOWLEDGEMENTS

The authors wish to thank the local authorities of the SUCH (subdivision of Urbanism, Construction and Housing) particularly Mr. Amar Mansoul and Mr. Mohamed Kessayssia, project manager of the realization of 200 dwelling in this period for their precious assistance. As well as, all the residents of 80 apartments of the case study, who contributed to the undertaking of this survey by granting access to the dwellings and providing valuable information.

8. NOMENCLATURE

F: Number of bedrooms in the apartment with a separate kitchen (kitchen & bath not included)

F2: one bedroom + living room

F3: two bedrooms + living room

F4: three bedrooms + living room

F5: four bedrooms + living room

9. REFERENCES

[1] Mazouz S., Torkia A. Quantitative evaluation of the performance of a wind tower for natural ventilation and passive cooling in a hot and arid area of Southern Algeria: A case of Ouled Djellal in Algeria. Journal of Architecture and Planning, Riyadh., 2014/1435H; 37-47.

[2] Montazeri H. and Azizian R., Building and Environment, 2008, 2193–2202.

doi: 10.1016/j.buildenv.2008.01.005

[3] Jamal Khodakarami, Mohammad Reza Aboseba. Impact of Opening´s Number and Outdoor Flow direction on the Indoor Vertical Flow Velocity in winds catchers. International Journal of Renewable Energy Research., 2015, Vol.5, No.2

[4] Seyedeh Mahsa Ghamkhar, Seyedeh Melika Ghamkhar. Applying Zero Carbon Architecture Strategies to Mitigate Climate Change in the Middle East and North Africa (MENA). In international conference on climate change, 8th to 10th January 2017.

[5] Rosa Schiano-Phan & Brian Ford: Post Occupancy Evaluation of non-domestic buildings using downdraught cooling: Case studies in the US. PLEA 2008 – 25th Conference on Passive and Low Energy Architecture, Dublin, 22nd to 24th October 2008

[6] Ahmadreza Foruzanmehr, Fergus Nicol. Towards new approaches for integrating vernacular passive-cooling systems into modern buildings in warm-dry climates of Iran. Conference on Air Conditioning and the Low Carbon Cooling Challenge, Cumberland Lodge, Windsor, UK, 27th to 29th July 2008.

[7] Ahmadreza Foruzanmehr. Architectural Science Review, 2012, 55, 250:258
doi: 10.1080/00038628.2012.722070

[8] Gianluca Cadoni., Les systèmes de rafraîchissement passifs dans l'architecture contemporaine et la conception bioclimatique du bâtiment - Méthodologie d'analyse et évaluation de réalisations à travers le monde, 2012.
En ligne https://halshs.archives-ouvertes.fr/halshs-00745047

[9] Bouchahm Y., Bourbia, F., Belhamri, A., Renewable Energy 2011, 36: 898-906.
doi: 10.1016/j.renene.2010.08.030

[10] Bouchahm Y., Djouima, A., The experimentation of improved evaporative cooling wind tower in real office building, PLEA 2008, 25th Conference on Passive and Low Energy Architecture, Dublin, 22nd to 24th October 2008

[11] Djouima, A., Bouchahm Y., Bourbia, F., Torkia, A. Journal of fundamental and science; 2018, 10 (1): 344-364.
doi: 10.4314/jfas.v10i1.25

[12] Ministère de l´habitat et de l´urbanisme., Direction des programmes d´habitat et de la promotion immobilière, Prescriptions techniques et fonctionnelles applicables aux logements sociaux, Octobre 2007.

[13] Journal Officiel de la république Algérienne n°6, 27Janvier 2013 section 3 article 31 et section 4 art 31- 45.

[14] Code de la Construction et de l´Habitation en France (CCH). Taille des logements.

En ligne https://mrlacroix.files.wordpress.com/2016/06/taille-des-logements1.pdf

[15] Loi relative à la Solidarité et au renouvellement urbain (SRU) n° 2000-1208 du13 décembre 2000.

En ligne https://www.habiter-autrement.org/11.construction/...11/habitat_intermediaire.pdf

How to cite this article:
Torkia A, Mazouz S, Djouima A. Users perception of a wind tower for passive cooling in hot dry area of southern Algeria: a case of Ouled Djellal Biskra. J. Fundam. Appl. Sci., 2018, *10(3), 477-499.*