PROPOSED NATURAL METHODS FOR ENHANCING THERMAL COMFORT AND REDUCING ELECTRICITY CONSUMPTION IN HUN CITY IN LIBYA

[1]OSAMA OMAR HASEN ESHKORFU, [2]ZULKIFILI BIN HANAFI

[1,2]School of Built Environment; Department of Architecture, Infrastructure University Kuala Lumpur Malaysia (IUKL); Jalan Ikram, Kajang 43000 Malasyia
E-mail: [1]osama.shk72@gmail.com, [2]zulkiflihanafi@iukl.edu.my

Abstract - The climate in any place is affected by many factors such as weather seasons and the temperature changing in night and day. Without using additional methods and techniques for thermal comfort, the outdoor increase the difficulty of archive the thermal comfort in houses. The electrify mechanical like air conditions is used widely to achieve the houses thermal comfort. The main challenge of the electricity mechanical is the large energy consumption which leads to increase the money and resources expenses of people and country. The main aim of this study is to explore the current situation of energy consumption and thermal comfort in Hun city in Libya. In order to address this objective, a questionnaire survey with 31 Houses in Hun city was conducted. The significant results of data analysis show that the thermal comfort in the Houses is achieved using electricity, mechanical such as air conditions and fans which expense peoples' money due to the large consumption of electricity. This study has recommended some natural shading and shadows methods to enhance the thermal comfort in houses and reduce the electricity consumption.

Keywords - Electricity Consumption; Thermal Comfort; Hot Dry Climate; Natural Shadows; Natural Shading

I. INTRODUCTION

According to Johansson (2006) the climate is defined as the natural weather condition in a specific area, city, or country (i.e. Hot, cold, or warm climates). The climate in any place is affected by many factors such as weather seasons and the temperature changing at night and day. The climate of outdoor plays important role in the thermal comfort of indoor buildings and houses. Hence, the people looking for thermal comfort in their houses, whatever the nature of outdoor climate (Müller et al., 2014). The thermal comfort of building and houses, conditions is known as the suitable temperature degree in the houses. Without using additional methods and techniques for thermal comfort, the outdoor climate plays important role in decrease or increase the temperature degree in the houses, which increase the difficulty of archive the thermal comfort in houses.

One of the most used approaches to address the houses thermal comfort is the mechanical approaches based on electricity power such as air conditions. Air conditions can be used to cool or heat the weather in the houses in order to achieve the thermal comfort (Aldossary et al., 2015). However, mechanisms like air conditions bring new challenge to people and countries. The energy consumption is one of the main challenges of the houses thermal comfort based on electricity mechanisms. Energy consumption leads to increase the money expenses of people (e.g. electricity bills), and increase the wasting of countries resources (i.e. gas or petrol).

In Libya, The using of electricity mechanisms to achieve the thermal comfort consumes a large amount of electrical energy in residential buildings equivalent to approximately 70% of the total bill value (Rationalization of electricity consumption SEC 2010). General Electric Company reports in Libya (Figure 1) indicated that in 2012, the proportion of residential building's electrical energy consumption is exceeded 36% of the total consumption of electric power, the industrial sector consumes about 11%, agriculture about 12%, the trade about 14%, and public facilities about 27% (Mokri et al., 2013: Report Company General Electric Libya in2012).

The problem of high electric energy consumption in Libya homes presents the importance of the natural thermal insulation of buildings roofs in order to reduce the heat leakage into the building and thus reduces the consumption of the used electric energy. Architecture engineers try to come with innovative ideas related to house design in order to reduce power consumption and achieve the thermal comfort in houses (Mokri et al., 2013). Various studies focus on the outer shell of residential buildings and how it is impacted by the surrounding environmental conditions and the impact on the house internal climate. The main factors of building design that may affect the outer building shell with surrounding environmental conditions are windows, sidewalls and roofs.

The buildings that are not designed to reduce the effect of surrounding environmental conditions generally depends on other electrical devices such as air- conditioning or electrical heaters to reach thermal comfort in summer and winter, which leads to an increase in electric power consumption rate especially for cooling and heating.

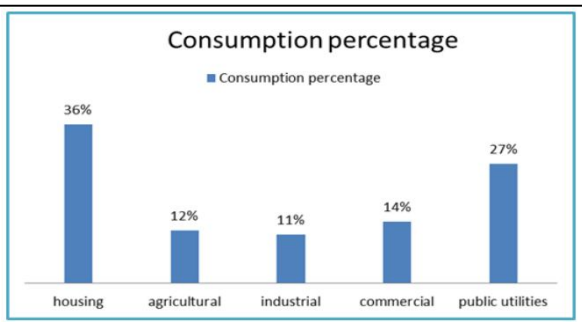


Figure 1: Percentage of electricity consumption per sector in 2012.

This study aims to explore the current situation of energy consumption and comfort in Hun city in Libya also proposed natural methods to enhance thermal comfort of houses and reduce the consumption of electricity energy. Hun city in Libya is selected as case study due to many reasons such as the climate of Hun city is mainly desert climate where the temperature in winter is considered as cool or cold, and the temperature in summer is hot (Aldbibi, 2007). Hun city suffers from the rigors of weather conditions which increase the difficulty of achieve the thermal comfort in houses.

II. RELATED WORKS

Architecture engineers try to come with innovative ideas related to house design in order to reduce power consumption and achieve the thermal comfort in houses. Various studies focus on the outer shell of residential buildings and how it is impacted by the surrounding environmental conditions and the impact on the house internal climate. The main factors of building design that may affect the outer building shell with surrounding environmental conditions are windows, sidewalls and roofs. The buildings that are not designed to reduce the effect of surrounding environmental conditions generally depends on other electrical devices such as air- conditioning or electrical heaters to reach thermal comfort in summer and winter, which leads to an increase in electric power consumption rate, especially for cooling and heating.

There are various ideas were investigated and several models of natural shadows were developed in the field of outer shell of residential buildings. Some studies focus on the material finished the external surface of building such as cement luster, stone veneer, marble cladding, and concrete tiles. The material of external surface plays important roles in the leakage or the reflection of outside temperature. Hamdan et al. (2012) conducted an experimental investigation that involves the selection of most efficient passive roof of buildings in Jordan. This was achieved by the fabrication of four identical test structures, each one was made by using mild steel angle and galvanized steel sheet. A 0.08 m layer thickness of reinforced cement concrete CRCC roof was cast over each one. Clay thermal insulation over the roof has been found the best material for cooling of building for better comfort conditioning in arid areas, while the white cement structure is the least efficient one.In a study conducted by Alavez-Ramirez et al. (2014), coconut fibre filled precast ferrocement roofing channel components were developed, their thermal behavior was characterized and its performance was compared to precast ferrocement-only roofing channel components in a real-scale prototype house built in CIIDIR facilities in Oaxaca, Mexico. The findings indicated that, coconut fibre filled precast ferrocement roofing channel components experience higher solar radiation intensity, but its thermal damping is 40% and its thermal lag of about three and a half hours. (Nahar et al. (2003) tested eight identical building prototypes to find the best insulated system that reduced the heat on the surface. The dimensions of theses building prototypes are 1, 28 ×, 61 × 1, 1 m3 with mild steel and galvanized steel sides and with a reinforced cement concrete roof. The roof insulation techniques are air void insulation, nocturnal cooling, painting the roof with white cement, covering the roof with Sania a local material, evaporative cooling and broken white glazed tile pieces.

The findings indicated that evaporative cooling found to be the best technique to reduce heat from the roof, which resulted in reaching the thermal comfort inside the buildings, but it needs a huge amount of water so it is suggested that using white glazed tiles stuck over the roof can be used to reduce evaporation and reduced water consumption.

Other studies of natural shadows focus on the color external surface of buildings such as light, medium, or dark colors. The dark colors allow the leakage of outside temperature while the light colors reflect the outside temperature. In a study conducted by (Hernández-Pérez et al., 2014) , the thermal performance of a concrete roof with and without insulation and with two colors has been analyzed using the finite volume method. The boundary conditions of the external roof surface were taken from hourly averaged climatic data of four cities. For the internal surface, it is considered that the building is air-conditioned and the inside air has a constant temperature. The interior surface temperature and the heat flux rates into the roofs were obtained for two consecutive days in order to assess the benefits of a cool roof in different climates. The single white roof configuration was able to reduce the interior surface temperature up to 28 °C at midday in comparison to a roof with the original gray color of concrete. On the other hand, the reflective coating kept the roof close to the inside air temperature in the case of the compound roof; just 3 °C above the set point during the hours with solar radiation.Gao et al.

(2014) conducted a study to investigate how colored roofs reduce the inner temperature of residential buildings and offices in seven Chinese cities which are Beijing, Harbin, Guangzhou, Changchun, Shanghai, Chongqing and Wuhan. The findings indicated that using a white roof instead of a gray roof reduces the inner temperature of buildings in all cities. It was found that a white coating roof saves daily 9% of energy for air conditioning in an office building in Chongqing city. In a factory in Guangdong City, it was found that a white coating roof reduces the inner room temperature from 3-4 degrees and roof heat flux by 66%. The study concluded, depending on experimental results and simulation, that white coating roofs found to be efficient in reducing the inner building temperature which saves energy used for cooling such as air conditioning.

Furthermore, there are studies conducted on the natural shading of outer shell of residential buildings. Various studies focus on surrounding the buildings by natural shading protection like the trees and plants, also the plants and tress is used to protect the building roofs from the outside temperatures.Simpson and McPherson, (1998) examined the possibilities for energy conservation in hot climatic conditions using tree shading. Simpson and McPherson, (1998) evaluate and simulate the effect of tree shading on energy use in housing in the 254 facility in California. They founded that the average in that planting three trees for each property is important to reduce the use of power, cooling, and the annual peak of 7.1% and 2.3%, respectively. On the other hand Higuchi and Udagawa (2007) assessed the impact of evergreen broadleaf deciduous trees as natural shading method to enhance the thermal comfort and reduce the energy consumption in houses. The researchers reported by planting these trees to shade buildings, savings of up to 20% on annual energy cooling.(Coutts et al., 2013) conducted a study to identify and assess certain methods to mitigate higher urban temperatures to reach thermal comfort. The study aims to find how green and cool roof's performance is depending on their design, vegetation species and watering system. A comparison of four rooftops including green roofs which are planted with Sedum and cool roofs which are coated with white elastomeric paint was conducted in Australia.

The findings indicated that irrigated green roofs reduce the surface heat than non-irrigating green roofs in summer midday. The findings also show that cool roofs are considered a benefit in terms of energy transfer into buildings as the service heat was reduced during the day La Roche and Berardi (2014)stated that Green roofs have been used for the purpose of energy saving in many countries. The potential abilities of green roofs for heating or cooling depend on two factors which are the building features and the climate conditions. Upon that, they conducted a study to measure the green roofs potential energy saving on different roofs which are a non-insulated, green roof, an insulated traditional roof, and a green roof with the variable insulation system and an insulated green roof. These roofs were tested in hot dry region during winter and summer seasons. The findings indicated that the variable insulating system was found to be effective in adjusting the roof thermal capacity. The findings revealed that the variable insulation, green roof and insulated traditional roof obtained the highest indoor temperatures in winter while the insulated green roof and the non-insulated green roof obtained the lowest indoor temperature in summer.

The main gap of the various methods of shadow and shading of buildings is that these methods should be mutated adaptively depend on the temperature (climate) changing of the buildings environment. The regions of hot dry climate like Libya country, the temperature in winter is considered as cool or cold, and the temperature in summer is hot. Also, the temperature is change rapidly when moving from the day to night. Therefore, some shadow and shading could suitable for specific season or period of day while other variables suitable for other seasons or period of day.

III. RESEARCH METHOD

The Hun City environment represents the main case study of this research. The community of this study is composed of of 2850 units of houses; 1000 District the struggling of one floor houses, 600 of District Five Hundred of one floor houses, 500 houses of two floors, and 750 houses of three floors. According to sampling selection of Sekaran (2006), the data collction sample must be around 379. For this study, a pilot study was conductd in order to invistgate the challenges and situation of thermal comfort in the study area. According to Sekaran (2006), the suitable pilot size of the questionnaire is about 5% - 10% of the actual sample. Thus, the minimum pilot size should be 19 houses. In order to examine the challenges of energy consumption and comfort in Hun city, a semi structured questionnaire was conducted with 31 heads of household in Hun city. The conducted survey was mainly investigated the current situation of electricity consumption and thermal comfort in the study area. On the other hand, a literature of the various natural methods of bullrings and houses shadows and shading was reviewed to propose useful natural methods to enhance the thermal comfort and reduce the electricity consumption in the study area.

IV. RESULTS AND DISCUSSION

The questionnaire of this study consists of four parts which are demographic data; houses information; electrify consumption, and thermal comfort.

Regarding to demographic data,thegender of respondents (heads of household) is mixed between male (68%) and female (32%) which indicates the usefulness of collected data based on different gender opinions. On the other hand, the majority of respondents' ages is between 35-39 years (32%), and between 40-64 years (36%). Respondents of these ages could have good knowledge about the thermal comfort and energy consumption in their houses. Moreover, most of respondents are educated (45% are university level, 13% are master level, and 13% are PhD level) which indicates the usefulness of collected data based on good understanding of survey items. Furthermore, most respondent are live in the city from since birth (61% of all respondents). These reflect good understanding of city climate over long years. Additionally, most of respondents' are live in their houses for more than 10 years (74%). Thus, the respondents understand the situation of houses thermal comfort and energy consumption. Lastly, the persons that live in respondents houses are vary form 1-more than 8 persons. Therefore, the collected data represents the thermal comfort and energy consumption based on various numbers of people who live in houses. Table 1 presents the descriptive analysis of the demographic data.

Table 1: Descriptive analysis of the demographic data

Variable		Frequency	Percentage
Gender	Male	21	68%
	Female	10	32%
Age	18-34 years	6	19%
	35-39 years	10	32%
	40-64 years	11	36%
	more than 64 years	4	13%
Levels of education	High School	9	29%
	University	14	45%
	Master degree	4	13%
	PhD	4	13%
How long did you live in the city?	Since birth	19	61%
	Less than 5 years	3	10%
	From 5to 20 years	2	6%
	More than 20 years	7	23%
How long have you been living in this house?	Less than 5 years	4	13%
	From 5 to 10 years	4	13%
	From 10 to 15 years	9	29%
	More than 15 years	14	45%
How many persons are living in the house?	1- 2 persons	1	3%
	3-4 Persons	9	29%
	5-6 Persons	12	39%
	7-8 Persons	8	26%
	>8 Persons	1	3%

Regarding to house information, the respondents' houses are occupied for more than 6 hours per day (87%) which reflect the importance of enhancing thermal comfort and reducing energy consumption in these houses. Most ofthe respondents' houses are one and two stories (87%), with size area between 100-300 M2 (84%), and more than 5 rooms (61%).All of houses roofs colors are medium or dark colors; these colors allow the temperature leaking from outdoor environment. Most of houses external surface materials are cement Laster (35%), or concrete tiles (51%).In the context of houses information, the effeciency of natural shading and shadow methods in the respondents houses are mostly poor. Thus, the natural shading and shadow methods are

not used to enhance the thermal comfort in the houses. Table 2 presents the descriptive analysis of the house information.

Table 2: Descriptive analysis of the house information

Variable		Frequency	Percentage
How long is your dwelling occupied per day on average (not including hours of sleep)	3 hours per a day	3	10%
	3-6 hours per a day	1	3%
	6-10 hours per a day	12	39%
	over 10 hours per a day	15	48%
What area is the sizeof your house?	100-150 m^2	7	23%
	151-200 m^2.	7	23%
	201-300 m^2	12	38%
	301-500 m^2	5	16%
What type of dwelling do you live in?	One story house	12	39%
	Two story house	15	48%
	Three story house	4	13%
How many rooms are there in the your house?	1 Rooms	0	0%
	2 Rooms	0	0%
	3 Rooms	0	0%
	4 Rooms	10	32%
	5 Rooms	2	7%
	More than 5 Rooms	19	61%
What is the color the roof of your house now?	Light Color	0	0%
	Medium color	14	45%
	Dark Color	17	55%
What is the material finished the external surface of your house now?	CementLaster	11	35%
	stone veneer	2	7%
	marble cladding	2	7%
	wood material	0	0%
	concerete tiles	16	51%
Efficiency of Shading Devices that used around houses	Poor	21	68%
	Fair	9	29%
	Good	1	3%
Efficiency Shadow external on houses roofs	Poor	27	87%
	Fair	3	10%
	Good	1	3%

Based on the above Table 2, the shadow and shading methods is not used in the respondents' houses. However, the thermal comfort of houses is critical issue because these houses are occupied by persons for long time per day. Researchers such as La Roche and Berardi (2014), Hernández-Pérez et al. (2014), and Hamdan et al. (2012) were pointed that the natural shadow and shading methods are important to enhance the thermal comfort of houses. Without proper shading and shadow methods, the energy consumption will be increased to achieve the thermal comfort due to large area of respondents' houses (100-500 M, and more than 4 rooms).

Regarding to energy consumption in the respondents house, there are many items were analyzed. All of respondents houses are used the electricity and gas energies to achieve the thermal comfort intheir houses. Most

of respondents are considered that the level of energy houses in their houses is medium (45% of respondents) or high (45% of respondents). 90% of respondents see that the level of energy consumption in summer session is high. Also, 87% of respondents see that the level of energy consumption in winter is high. Most of respondents (97% of respondents) expend more than 600 Dinars as monthly cost of energy consumption. Table 3 presents the descriptive analysis of the energy consumption.

Table 3: Descriptive analysis of the energy consumption

Variable		Frequency	Percentage
Energy Types in respondents houses	Electricity	6	19%
	Gas	0	0%
	Electricity and gas	25	81%
	Other	0	0%
Level of Energy Consumption	Responsible	3	10%
	Medium	14	45%
	High	14	45%
Level of Energy Consumption in Summer Session	Responsible	1	3%
	Medium	2	7%
	High	28	90%
Level of Energy Consumption in Winter Session	Responsible	1	3%
	Medium	3	10%
	High	27	87%
Monthly Costs of Energy Consumption	Less than 200 Dinars	1	3%
	200-400 Dinars	14	45%
	400-600 Dinars	16	52%
	More than 600 Dinars	0	0%

The results in the above Table 3 confirmed the problem of energy consumption in Libya to achieve the thermal comfort in houses. Mokri et al. (2013) and RCGEL (2012) argued that the energy consumption is oneof the most main challenges in Libya. It can be noticed from the results that the level of energy consumption is high in both sessions (winter and summer). This because that the climate of Hun city is hot in summer and cold in winter (Aldbibi, 2007) which require energy consumption in both sessions in order to achieve the thermal comfort.

Regarding to descriptive analysis of thermal comfort in Table 4,the air conditions and fans are the main mechanisms based on electricity energy that used to cool the houses in summer session. The air conditioning and fans are almost used all the day to achieve the thermal comfort in summer session. On the other hand, the air conditions and electric radiators are the main mechanisms based electricity energy that used to heat the houses in winter session. The air conditions and electric radiators are almost used all the day to achieve the thermal comfort in winter session.

Table 4: Descriptive analysis of the thermal comfort

Variable		Frequency	Percentage
Cooling Mechanisms in Summer Session	AC	12	39%
	AC & Fans	18	58%
	Fans	1	3%
Period of Using Cooling Mechanisms in Summer Session	All Day	28	90%
	Evening and Night	3	10%
	Night	0	0%
	Evening	0	0%
Heating Mechanisms in Winter Session	AC	19	61%
	Electric Radiators	12	39%
	Other	0	0%
Period of Using Heating Mechanisms in Winter Session	All Day	28	90%
	Evening and Night	2	7%
	Night	1	3%
	Evening	0	0%

Based on the above Table 4, it can be concluded that the electric machines such as AC, fans, and radiators are used widely to achieve the thermal comfort in the respondents' houses.Aldossary et al., (2015) mentioned that the using of electric machines for houses thermal comfort brings new problems like high consumption of energy. Thus, the electric bills costs will be increased and the energy resources will be wasted.

Figure 2shows that the rate of houses temperature (ground and upper floor) is mostly warm or hot in summer session due to high temperature degree of Hun city climate in summer. Thus, the cooling mechanisms using electrical energy are used to decrease the houses temperature in summer session. This because the climate of Hun city in the summer is high (Aldbibi, 2007).

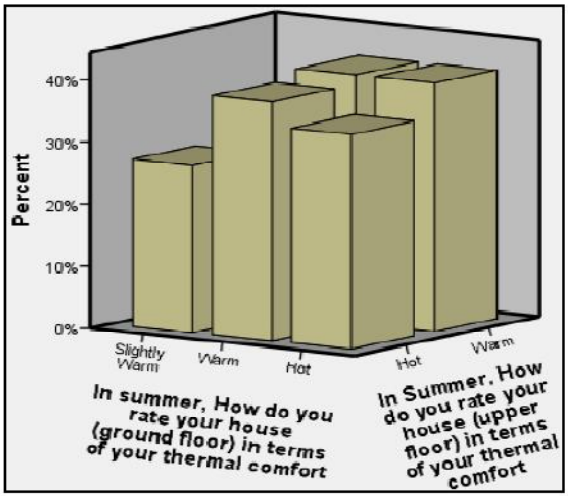


Figure 2: Temperature Rate in Summer Session in Hun City

Figure 3 shows that the rate of house temperature (ground and upper floor) is mostly cool or cold in winter session due to the low temperature degree of Hun city climate in winter. Thus, the heating mechanisms using electrical energy are used to increase the houses temperature in summer session. This because the climate of Hun city is cold in the winter (Aldbibi, 2007).

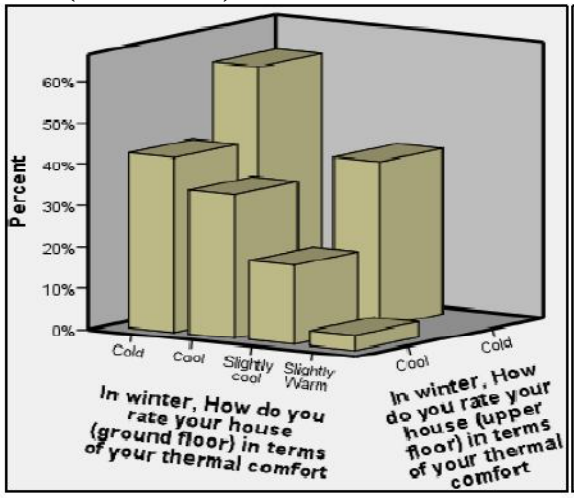


Figure 3: Temperature Rate in Winter Session in Hun City

Based on the survey findings, it can be noticed that that Hun city climate is changing rapidly from winter to summer and from summer to winter. This rapid changing leads the people to use the eclectic energy to achieve the thermal comfort in their houses and consequently increase the expenses of energy consumption. Referring to houses information part, the houses in Hun city are not supported by natural shading or shadow methods to enhance the thermal comfort adaptively and then reduce the energy consumption and expenses.

V. RESEARCH LIMITATIONS

The main limitation of the previous research is weakness of the suggested natural shadow and shading to address the frequent change of dessert climate. The dessert climate is hot in summer and cold in winter. On the other hand, the climate is changed from day to night. Thus, it is necessary to utilize adaptive natural methods of shadow and shading to achieve the thermal comfort in houses whatever the situation of outside climate. Many researchers proposed natural methods and techniques of houses shadow and shading to enhance the thermal comfort (La Roche & Berardi2014;Hernández-Pérez et al., 2014;Hamdan et al., 2012). The main challenge of the various methods of shadow and shading of buildings is that these methods should be mutated adaptively depend on the temperature (climate) changing of the buildings environment. In the regions of hot dry climate like Libya country, the temperature in winter is considered as cool or cold, and the temperature in summer is hot. Also, the temperature is change rapidly when moving from the day to night. Therefore, some shadow and shading could suitable for specific season or period of day while other variables suitable for other seasons or period of day.Some previous works proposed natural shadows methods such as roofs colors, and surface materials to enhance the thermal comfort of houses (Gao et al.2014; Coutts et al., 2013). However, these methods are suitable for cooling or heating the houses temperatures, but not suitable to achieve the thermal comfort depend on the temperature changes (adaptive cooling and heating). Other related works were proposed the natural shading methods such as protect houses roofs or surrounding houses by trees. However, these methods is almost use for houses cooling rather than heating purposes.

VI. RESEARCH IMPLICATIONS

The integration between green roofs (shading) and color of roof materials (shadow) provided effective result to adjust the thermal comfort of houses adaptively based on the outdoor climate temperature (cooling in summer, and heating in winter). Thus, this research proposed the integration between green roofs

using suitable plants or trees architecture, and the suitable color of roofs materials in order to enhance the thermal comfort and reduce the energy consumption of houses in Hun City. The proposed natural methods are important for Hun city houses due to following reasons:

1. Reducing electricity consumption in residential buildings, which contributes to reducing the production of electricity and the expenses of thermal comfort in houses.
2. Attempting to use insulation materials the ceiling of the output of traditional architecture which is characterized by the use of local materials which cost is lower than the electric mechanisms installing, deploying, and maintaining.
3. The electric mechanisms (central cooling or heating) feeding by gas or petrol may lead to weather side effects (i.e. Colostrum pollution). These effects would be reduced using natural techniques and materials in building design.

CONCLUSION AND FUTURE WORKS

This study explores the current situation of thermal comfort and energy consumption in Hun city houses. For this purpose a questionnaire survey was conducted. The significant findings show that the thermal comfort in Hun city houses is achieved using electricity mechanisms. Electricity mechanisms are used for along time per day to heat the houses in winter or cool houses in winter. Thus, the electricity energy consumption and expenses are high. This presents the importance of natural shadows and shading methods to enhance the thermal comfort and reduce the energy consumption in the Hun city house. The main gap of natural shadow and shading methods is that each method is suitable to heat or cool the house temperature, but not effective to cool and heat the house adaptively based on the dynamic change of outdoor temperature. The integration between green roofs and color of roof materials considered as an effective combination to adjust the thermal comfort of the houses adaptively. In the future, a study could be conducted to determine useful combination between architecture of green roofs using suitable plants or trees, and the suitable color of roof materials in order to enhance the thermal comfort of Hun city houses whatever the temperature degree of outdoor climate.

REFERENCES

[1] Alavez-Ramirez, R., Chiñas-Castillo, F., Morales-Dominguez, V., Ortiz-Guzman, M. & Lara-Romero, J. 2014. Thermal Lag And Decrement Factor Of A Coconut-Ferrocement Roofing System. Construction And Building Materials, 55, 246-256.

[2] Aldbibi. M. 2007. Appropriateness of modern housing in Hun climate Desert region. Master Thesis,

[3] Aldossary, N. A., REZGUI, Y. & KWAN, A. 2015. An investigation into factors influencing domestic energy consumption in an energy subsidized developing economy. Habitat International, 47, 41-51.

[4] Coutts, A. M., DALY, E., BERINGER, J. & TAPPER, N. J. 2013. Assessing practical measures to reduce urban heat: Green and cool roofs. Building and Environment, 70, 266-276.

[5] Gao, Y., Xu, J., Yang, S., Tang, X., Zhou, Q., Ge, J., Xu, T. & Levinson, R. 2014. Cool Roofs In China: Policy review, building simulations, and proof-of-concept experiments. Energy Policy, 74, 190-214.

[6] HAMDAN, M. A., YAMIN, J. & HAFEZ, E. M. A. 2012.Passive cooling roof design under Jordanian climate. Sustainable cities andSociety, 5, 26-29

[7] Hernández-Pérez, I., Álvarez, G., Gilbert, H., Xamán, J., Chávez, Y. & Shah, B. 2014.Thermal Performance of a Concrete Cool Roof under Different Climatic Conditions of Mexico. Energy Procedia, 57, 1753-1762.

[8] Higuchi, y. & Udagawa, M. Effects of trees on the room temperature and heat load of residential building.Building simulation, 2007.

[9] Johansson, E. 2006. Influence of urban geometry on outdoor thermal comfort in a hot dry climate: a study in Fez, Morocco. Building and environment, 41(10), 1326-1338.

[10] Mokri, A., ALI, M. A. & EMZIANE, M. 2013. Solar energy in the United Arab Emirates: A review. Renewable and Sustainable Energy Reviews, 28, 340-375

[11] Müller, N., Kuttler, W., & Barlag, A. B. (2014).Counteracting urban climate change: adaptation measures and their effect on thermal comfort.Theoretical and applied climatology, 115(1-2), 243-257.

[12] Nahar, N., Sharma, P. & PurohiT, M. 2003.Performance of different passive techniques for cooling of buildings in arid regions. Building and Environment, 38, 109-116

[13] Roche, P. & Berardi, U. 2014.Comfort and energy savings with active green roofs. Energy and Buildings, 82, 492-504.

[14] Simpson, J. R. & Mcpherson, E. G. 1998. Simulation of tree shade impacts on residential energy use for space conditioning in Sacramento. Atmospheric Environment, 32, 69-74.

★★★