Preserve Maximum Thermal Comfort by Energy Consumption Substitution in HVAC System: a case study in Mosul

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Abstract

Thermal comfort equipment, such as air conditioning, show the amount of energy consumed by equipment. Heating, ventilation, and air conditioning (HAVC) is a popular type of equipment that consumes a large part of produced electricity. Thermal comfort devices are high-power consumers, requiring 40% of total generated energy. This research is interested in deriving parameters linked with thermal comfort by defining the real problem of energy and thermal comfort trade off. The findings of this research entail the establishment of hypotheses in this respect in agreement with previously completed investigations.

Keywords: HVAC, Thermal Comfort, Over Heating, Energy, Air Conditioning.
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1 INTRODUCTION

The constructions including residential, commercial, industrial premises are contributing of 25% of the total energy consumed in the world; in some occurrences, the energy consumption may exceed this level reaching 40%. This energy is being consumed in forms heating, ventilation, air conditioning and cooling through deployment of HVAC systems (SolanoeOlivares, et al., 2019). Major resource of energy consumption is the heat which may create an equilibrium in energy formula. The overheat gaining as well as over heat losing are both troublesome. In the context of buildings, exchanging of heat is taking place through buildings surfaces/faces including the walls (whichever in direct contact with sun/light) and top-roofs. Basically, energy consumption is accounted for costs which are proportional to the level of consumption. Recalling the cost of energy generation and other factors associated with the same such as fuel cost, energy harvesting is main goal of almost every operation including manufacturing, fabrication, cooling, heating, etc. Two major concerns are being considered while designing/constructing of buildings namely thermal comfort and energy computation. The human response/satisfaction with the surrounding thermal environments fluctuation is termed as thermal comfort whereas the second factor of is related to the economical worthiness of the said thermal comfort which is termed as energy consumed while implementing a specific program of thermal comfort. The amounts of energy conception while using of traditional air cooling, heating and conditioning is a function to various factors including geometrical area, location, environmental factors, weather and human satisfaction. Both active and passive technologies have been used for energy utilization at constructions. In order to understand the both influencing factors and technologies of air

conditioning cooling and heating at indoor environments, a survey based study is proposed in order to derive best thermal comfort-energy balancing. The remaining sections of this proposal includes problem formulation, literature survey and proposed methodology.

2 THERMAL COMFORT

The trade-off between the thermal comfort and energy is remained as insisting problem that is encountered while adopting of the heating, ventilation and air conditioning (HVAC) systems. Those systems are mainly made for regulating thermal comfort to the level insuring the human satisfaction. Thermal comfort is achievable in account of energy consumption and environmental emissions (Zhang, et al., 2020). Referring climate data (Kang, et al., 2017), temperature is very low during cooling seasons and moderated during hot seasons, thus, air conditioning systems including various cooling and heating systems are highly populated. Considering the community of constructions industries in Iraqi northern state of Kurdistan, the energy utilization and management is crucial. However, the constructions projects of the state are leaked for robust strategy for energy-thermal comfort regulation. Deployment of highly powered HVAC systems without concerning the energy problems and emissions is an obvious act in the state which can be regarded to awareness shortage about the globalized standards. From the other hand, this can be considered as cumulative issue since large portion of the existing cooling, heating and air conditioning machineries are old in age and inheriting the last decades energy norms.

The problem has another root as leak of electrical energy production is already experienced in the state. Energy is being produced locally using diesel generators which help in fulfilling the energy requirements in big constructions alike companies, hotels, hospitals, factories, etc. The cost of using this alternative is an additional burden on individuals and businesses owners especially as green energy alternatives such as photovoltaic and wind turbines are not seriously adopted. Additionally, classical construction technologies involving regular reinforced concrete slabs (RCC) and none isolated bricks/materials are most dominant in the state's buildings.

Most of the previous research activities which were conducted on energy consumption control and efficiency enhancement of the air-conditioning, cooling and heating systems are considered active and passive approaches which are by whole working for maintaining a thermal environments on particular levels by avoiding the factors behind temperature lose and gain. One of the passive technologies for creating a balance between the thermal comfort and energy consumption is using greenery roofs and vertical greenery systems (VGS) (Hao, et al., 2020). The VGS and GR has resulted in reduction of thermal variation between the day and night aa well as correcting of energy saving by 8%. VGS and GR technology is demonstrated in Figure 1.

Figure 1: A demonstrating of greenery roofs and walls (Hao, et al., 2020).

The income of individuals is basically the main factor in considerations of thermal comfort at residential buildings. (Goldsworthy, et al., 2019) is suggesting vulnerability measures to be enforced by the local authorities composing of regulations and roles the delimits the certain configurations of air conditioning, cooling and heating systems. It was realized however, the individuals income is not the only constrain to be considered while studying the energy bill and thermal-comfort trade-off. Factors alike, age of individual, location, availability of other generation systems alike solar panels and wind turbines may participate together for changing this trade-off.

In many circumstances where the human occupancy is said to be stochastic, the analysis of factors influencing the energy consumption in cooling systems is difficult using the normal quantitively methods. (Li, et al., 2020) has suggested using of data mining technologies in order to study the factors participating in energy formula of university campus; algorithms alike Random Forest (RF), K-nearest neighbour (KNN), etc were used for evaluating the attributes alike humidity, pollution, human population etc impact on energy conception.

(Che, et al., 2019) mentioned that heat, ventilation and air conditioning system (HVAC) is responsible of large portion of energy consumption in residential buildings. There is strong tie between the energy consumption by HVAC and factors alike air pollution and humidity. The approach proposed by (Che, et al., 2019) involves using pre-stages that can be integrated with HVAC that involves air pollution filtering by adding external filters (i.e. aluminium filtration) to the system and using de-humidity filtering. This approach is folded under the method called as retrofitting of traditional systems by implementation of extra devices such as filter as sensors with efforts to decrease the energy consumption. The same has contributed to reduce the energy by 30 to 60 percent as be (Che, et al., 2019).

As per (Winkler, et al., 2020), faults rose in the HVAC systems are responsible for substantial portion of energy losses. It has been said that20.7 Twh/y are the losses due to the installation faults. Such faults can be regarded to human error and causing a substantial overall losses. Another type of indoor air conditioning that highly about air ventilation is the very deep underground subways stations, such type of stations are popular in London (Figure 2). Due to the bad air quality on such stations, air filtration for pollution reduction is performed and hence the energy consumption is reduced by 30 %.

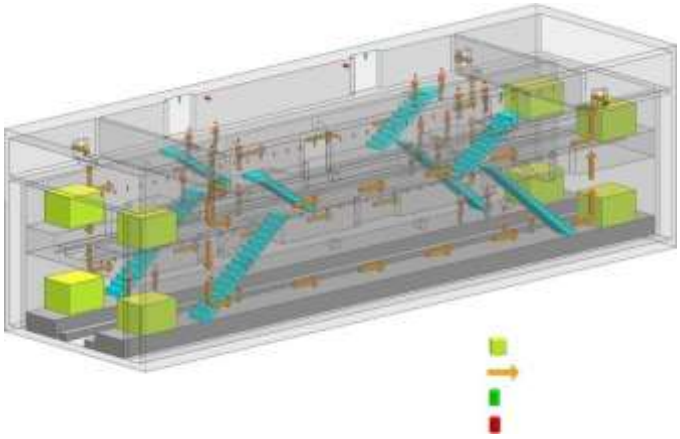

Figure 2: Subway station structure (Yin, et al., 2020).

(Torres, et al., 2020) is discussing the energy waste due to high power consumed by HVAC systems in the tourism fields. Study mentioned that 114 Wh/m2/y is been consumed for air conditioning in organization alike four star hotels. Considering this circumstances, the none conventional resources of energy such as photovoltaic may be used to replace the traditional power resources (fuel based); the same may participate to reduce the cost of energy.The glazed buildings such as airports are hit by direct sun rays especially during the summers, at (Pichatwatana, et al., 2017), study mentioned that main reason of the thermal discomfort in glazed organizations/buildings is regarded to the high temperature of the glazed surface which may remain around 56 degree even when the indoor thermal level of the ground (floor)

remains in good thermal level. The thermal discomfort may remain although good thermal condition of the indoor flooring. The study of (Li, et al., 2019) make a use of the so-called intermittent operations of the air-conditioning systems at the residential buildings for maintaining of good indoor thermal temperature as well as achievement of certain range of saving in the energy bills. From the other hand, it was suggested using solar based air-conditioning system that is populated as solar driven liquid desiccant air condition system as demonstrated in Figure 4, (Chen, et al., 2020). another approach demonstrated by (Homod, et al., 2021 (in press)) is proposing upgrading the air conditioning systems as well as the buildings into such forms where more solar isolation and more energy saving is achieved.

New terminologies namely Ambient air conditioning (AAC) and Task air conditioning (TAC) are reviewed at (Shiming, et al., 2018) which are standing for air conditioning systems that are integrated with beds providing good thermal comfort at lower energy while sleeping.

3 URBAN DEVELOPMENT

The current trend of thermal control is made by trying another techniques that considered as primitive techniques which are not really related to the technical design of air conditioning. The main approach od development of air conditioning system is maintaining equilibrium level between the absorption of heat and radiation of heat. That is made in accordance to the so-called human thermal comfort that discussed earlier. Using technologies such as architecture in order to implement the required thermal equilibrium. Green buildings that are growing plants on the top roof and on the surroundings are found more thermal efficient that those without plantation (Homod, et al., 2021 (in press)). Studies are conducted in calculation of the energy consumed before and after the plantation. Results found those buildings with plantation are more thermal conservative and less consuming of energy in terms of air conditioning. Another study is conducted to evaluate the impact of trees plantation on the thermal level at outdoor environments (SolanoeOlivares, et al., 2019), the experiment was about evaluating the temperature in summer days one various out door places such as roads, parking places, buildings, etc. it was found that temperature under shadowing places is much lesser that none shadowed places. The greenery places such as open gardens forests out of the big cities are found vital for thermal reduction (Li, et al., 2019). The scale of temperature reduction after deployment of greenery objects such as trees is contributing in energy preservation process. Table 1 is demonstrating the most relevant studies in this regard.

Table 1: Relevant Literature attempts for greenery approaches for thermal equilibrium.

(Hao, et al., 2020).	For maintaining the thermal environments on particular levels by avoiding the factors behind temperature lose and gain. One of the passive technologies for creating a balance between the thermal comfort and energy consumption is using greenery roofs and vertical greenery systems (VGS)

(Goldsworthy, et al., 2019)	Rrealized however, the individual's income is not the only constrain to be considered while studying the energy bill and thermal-comfort trade-off. Factors alike, age of individual, location, availability of other generation systems alike solar panels and wind turbines may participate together for changing this trade-off.
(Li, et al., 2020)	Analysis of factors influencing the energy consumption in cooling systems is difficult using the normal quantitively methods; algorithms alike Random Forest (RF), K-nearest neighbour (KNN), etc were used for evaluating the attributes alike humidity, pollution, human population etc. impact on energy conception.
(Che, et al., 2019)	The approach involves using prestages that can be integrated with HVAC that involves air pollution filtering by adding external filters (i.e. aluminum filtration) to the system and using de-humidity filtering.

(Winkler, et al., 2020),	Faults rose in the HVAC systems are responsible for substantial portion of energy losses. It has been said that20.7 Twh/y are the losses due to the installation faults.
(Torres, et al., 2020)	Study mentioned that 114 Wh/m2/y is been consumed for air conditioning in organization alike four star hotels. Considering this circumstances, the none conventional resources of energy such as photovoltaic may be used to replace the traditional power resources (fuel based); the same may participate to reduce the cost of energy.

(Pichatwatana, et al., 2017)	Mentioned that main reason of the thermal discomfort in glazed organizations/buildings is regarded to the high temperature of the glazed surface which may remain around 56 degree even when the indoor thermal level of the ground (floor) remains in good thermal level.
(Li, et al., 2019)	To make a use of the so-called intermittent operations of the airconditioning systems at the residential buildings for maintaining of good indoor thermal temperature as well as achievement of certain range of saving in the energy bills.
(Chen, et al., 2020)	It was suggested using solar based airconditioning system that is populated as solar driven liquid desiccant air condition system.
(Homod, et al., 2021 (in press))	Upgrading the air conditioning systems as well as the buildings into such forms where more solar isolation and more energy saving is achieved.
(Shiming, et al., 2018)	New cooling technologies namely Ambient air conditioning (AAC) and Task air conditioning (TAC) are reviewed

4 HYPOTHESIS DEVELOPMENT

For getting the required data inputs which to be analysed hereafter for fulfilling the study goals and objectives the following steps are proposed:

Nominating group of individuals for defining of study sample from (normal bodies), mechanical engineers, civil engineers, urban designers and contractors from different sites more likely row houses, apartments, commercial towers, consultation companies, etc. Quantitively data collection through survey of questionnaires that is distributing amongst the study sample mentioned in above. Concluding the recommendations and observations with reference to the results obtained from the data analysis step for evaluating the relationship among the problem variables: energy, thermal comfort, environmental emissions and urban roles. Thus, following hypothesises can be formed:

H1: The thermal comfort is most demandable more than any other factors which are expected from HVAC systems.

H2: The cooperation between different specializations including mechanical and civil an well as electrical engineers and designers is must to ensure good trade off in energy-thermal comfort complex.

H3: Vertical greenery systems (VGS) and greenery roofs (GR) are one of the outstanding solutions in thermal preservation at constructions and highly feasible to be executed in the state.

H4: Handful energy optimization standards are taken by the concern building are capable to cop with required minimum energy-thermal comfort demand.

H5: Retrofitting is highly possible in the existed constructions irrespective of its age and purpose.

5 DISCUSSION AND CONCLUSION

This paper discusses the problem of air conditioning in light of two factors namely thermal comfort and energy. Those two factors are direct proportional in such way that more thermal comfort is required more power per time factor (energy). Air conditioning is proved to be the most energy consuming appliances

that consume more than 40% of total urban energy generation.Several approaches were identified in the literature on air conditioning efficiency improvement. Considering that some countries are in sever thermal activities (temperature in the shadow may cross 50 centigrade), the reequipment of efficient and cost conscious approach for performance improving of cooling systems is essential to reduce the load on power systems and to ensure the maximum thermal comfort. Adaptation of plantations and greenery environments in the surrounding is reducing the temperature to a noteworthy level. Vertical greenery systems (VGS) are shown good performance on the same. This approach can be adopted by allowing the tree branches to propagate all over the area where the system is applied i.e. on the walls and well as the roof top. It was realized that fixation of accurate thermal sensor on the air conditioning system that acts to cut off the cooling/ heating whenever particular level of thermal comfort is reached. Cutting off the cooling/heating upon reaching particular thermal comfort is vital for reducing of energy. From the other hand, in some environments alike metro stations located on underground, the requirement of special air conditioning system that is able to ensure the thermal comfort as well as to inject the oxygen whenever its levels drop. According to the reviewed studies, five hypothesis are established that are subjected to analytical regime: H1: The thermal comfort is most demandable more than any other factors which are expected from HVAC systems.

H2: The cooperation between different specializations including mechanical and civil an well as electrical engineers and designers is must to ensure good trade off in energy-thermal comfort complex.

H3: Vertical greenery systems (VGS) and greenery roofs (GR) are one of the outstanding solutions in thermal preservation at constructions and highly feasible to be executed in the state.

H4: Handful energy optimization standards are taken by the concern building are capable to cope with required minimum energy-thermal comfort demand.

H5: Retrofitting is highly possible in the existed constructions irrespective of its age and purpose.

One of the essential aspect for assuring of thermal comfort even without spending on energy hike is efficient interior designby locating of the furniture such as beds on direction of air flow i.e. in front of balcony door where the personal thermal comfort can be guaranteed with minimum air condition power.

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