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Applying building energy simulation in the evaluation of the thermal behavior of an apartment in MOROCCO

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ABSTRACT

Nowadays, and on an international scale, controlling energy consumption in the buildings sector has become a human priority in the face of what it causes colossal damage to the environment. It is in this perspective that this work falls, we will carry out a study on a residential building located in a Moroccan semi-arid climate using a dynamic simulation software TRNSYS 17 in order to determine the energy needs and the thermal behavior of this habitat, thus to deduce the impact of these on the behavior of the occupant and on the energy consumption of the building.

Keywords: buildings energy efficiency, TRNSys 17 simulation, energy needs, thermal comfort.

1. INTRODUCTION

The International Energy Agency had already recommended, in 2012, to leave in the ground more than two thirds of the proven reserves of fossil fuels, because our consumption, by 2050, should not require more than a third proven reserves of fossil fuels so as not to exceed the maximum 2 ° C global warming by the end of the century [1].

Morocco has very few fossil fuel deposits and therefore still depends heavily on energy imports (2014: import of 89.4% of the energy used).

Total primary energy consumption has increased by around 5% per year since 2004, while the per capita increase is more moderate, at 3.6% per year. About a third of total primary energy consumption is spent on electricity production, which amounted to 37,446 GWh in 2018 [2]. Morocco produced 34,519GWh and imports the rest of Spain. Morocco has 33.5 million inhabitants.

In 2019, Morocco's electricity production capacities were 10,677 MW, divided between coal (31%), fuel oil and diesel (10%), hydroelectricity (22%), gas (25.8%) and wind power (9.4%).

Morocco aims to achieve a primary energy saving of about 12% and 53% renewable energy rate by 2030 by applying a new energy strategy which consists of adapting an energy efficiency plan in all different economic sectors [3].

Currently, the building sector (tertiary and residential) is the most energy-intensive sector; therefore it also has the greatest potential for long-term improvement in energy efficiency.

Several authors have reacted differently to energy management in the building sector in order to minimize the environmental impact. Among these studies we find building automation as a means of measuring efficiency [4]. Thus others have chosen to integrate renewable energies [5]. And other studies we prefer to efficiently control energy in the building by integration of passive techniques [6].

It is in this context that this work is part of which we will study the impact that some choices may have during the design of a building, on its energy balance and also on the thermal comfort of the occupant and this using the thermal simulation software TRNSys17.

Firstly a description of the example case study, where we will give all the necessary data for the simulation of our habitat. The next section describes the simulation of the building and the result. And finally we gave a conclusion with some work prospects

2. DESCRIPTION OF THE EXAMPLE CASE STUDY

2.1. Building

The building taken as case study is located in Settat, Morocco Table 1, and it is an apartment type with a net area of 110m2.

Table 1: the geographic coordinates of Settat city

City	*Altitude(m)*	*Longitude*	*Latitude*
Settat	365	-7,6160	33,0010

The apartment we took into consideration as a reference building for our study, features a three bedrooms, a kitchen, a living room, a bathroom and a corridor as show in Figure 1 whish illustrates the architectural plan of this reference building.

Figure 1: architecture plan and designation of different thermal zone

Thus the building has two facades, one facing east and the other facing south, with an overall window-to-wall ratio of 17, 5%.

$$WWR(\%) = \frac{\sum \text{Glazing area } (m^2)}{\sum \text{Gross exterior wall area } (m^2)} \qquad (1)$$

The exterior walls (not insulated) are composed of three layers (2cm of cement mortar, red clay brick with a thickness of 15cm and 2cm of cement mortar) with a total thickness of 19cm. The internal walls are composed of three layers (2cm of cement mortar, red clay brick 10cm and 2cm of cement mortar) with a total thickness of 14cm. The roof and the floor is a set called the slab, and in our case of study we have a solid reinforced concrete slab with a total thickness of 30cm composed by five layers (from roof to floor: 2cm of plaster, 16cm concrete slab , 6cm of cement mortar and 1cm of tile). Regarding the windows are in metallic frame with single glazing and are equipped with external stores. The following Table 2 shows us the different thermo physical properties of building construction elements [7].

Table 2:the thermal characteristics materials of the building envelope.

Materiaux	Conductivitet hermiqueλ(W/m.K)	Capacitether miqueCp(J/Kg.K)	Densite P(Kg/m^3)
Briquecreuse 10	0,179	760	884
Briquecreuse 15	0,197	760	640
Cement	0,72	780	2000
Platre	0,9	910	1800
Concrete slab	1,6	1000	2300
Tiles	0,84	840	1700

2.2. Meteorological data

Morocco is positioned in the north west of Africa on the Atlantic coast and that of the Mediterranean which gives it a great climatic variety in different regions of the kingdom, thus while basing on criteria of radiation, humidity and that temperature, the RTCM to subdivide the Moroccan kingdom into six climatic zones Figure 2 [8].

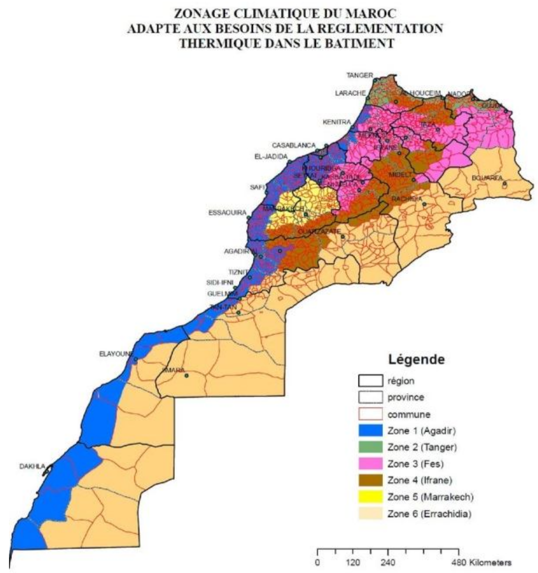


Figure 2: Climate zoning of Morocco

The city of SETTAT is endowed with a semi-arid climate (very hot in the summer period and very cold in the winter period) with an average annual temperature of 18.1C Figure 3

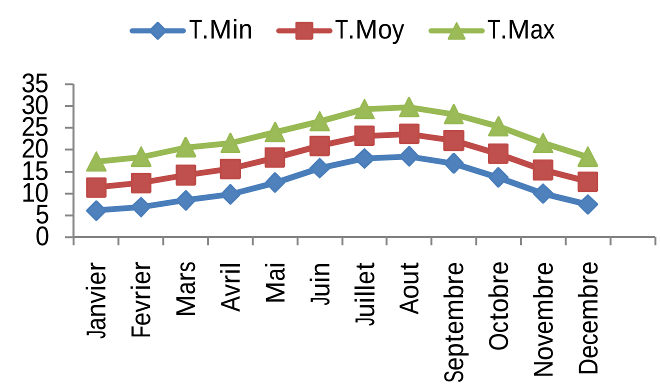
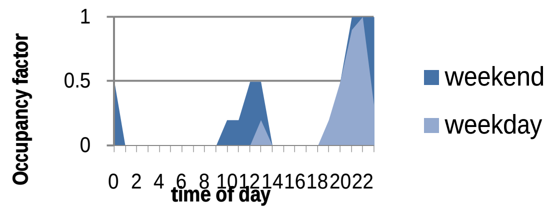
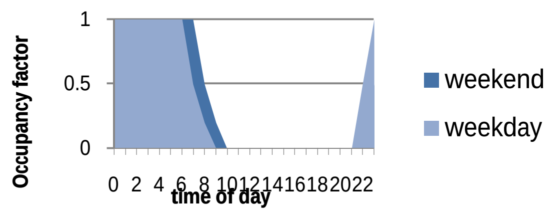
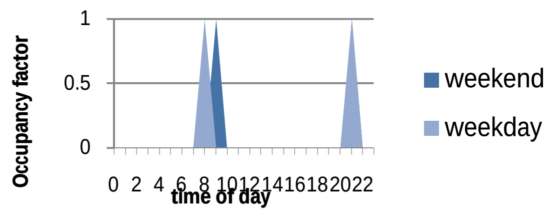
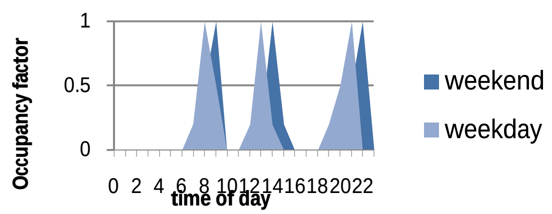
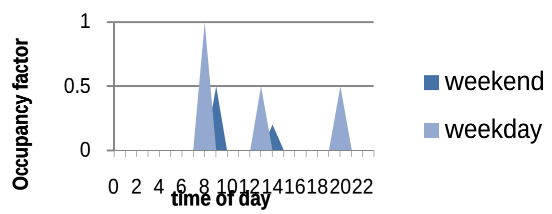


Figure 3: Annual outside air temperature

In order to perform our simulation under the trnsys 17 software, it is necessary to introduce meteorological data collected via the meteonorm[9] software, in which we will have the wind speed and direction, the hourly ambient temperature, the global solar irradiation and the relative humidity.

Table 3: Parameters set for the simulation

Thermal zone	Occupation (Person/m^2)	Illuminance (Lux)	senario
Living room	0,15	200	
Bedroom	0,16	100	
Bathroom	0,5	150	
Kitchen	0,23	250	
corridor	0,17	150	

2.3. Internal heat gain

A. Occupant

In order to determine the internal contributions of the occupants, we carried out two occupancy scenarios, one for the weekday and the other for the weekend (Saturday and Sunday) while taking into account that the apartment is occupied by a family who is consists of two adults and two children Table 3. TRNSys 17 simulation software represents a variety of types of occupant gains with reference to the 7730 standard [10].

B. Lighting and electrical equipment

Artificial lighting is a source of sensitive heat, which must be taken into consideration in our case study, we find in our reference building the use of two types of lamp, the incandescent lamps (the bedroom and living room) and fluorescent lamps (kitchen, corridor and in the bathroom) respectively with a power of 25 W/m2 and 8 W/m2.

Our apartment also includes electrical equipment which constitutes both sources of sensible and latent heat. As described in the following Table 3 of some equipment with their power and number of hours of use per day.

Table 4: the parameter for electrical equipment power and their duration work

Equipment	Gain (W)		Duration (h/day)	Number of item
	Sensible heat	Latent heat		
Freezer	500	-	10	1
TV	175	-	4	1
Laptop	250	-	3	3
Vacuum	50	-	0,5	1
Iron	230	270	0,5	1

3. SIMULATION OF BUILDING

Our habitat is equipped with a heating and air conditioning system while respecting the instructions of the NM ISO 7730 [10]which consists in setting a temperature of 20 C in the winter period and a temperature of 26 C in the summer period.

In order to carry out the simulation of the building, we worked with dynamic thermal simulation software, the TRNSYS17 [11].

The energy balance as the conductive and convective heat flux to the air node; is calculated by the multizone building model type56 [12], and defined by this equation:

$$\dot{Q}_{i} = \dot{Q}_{(surf,\, i)} + \dot{Q}_{(inf,\, i)} + \dot{Q}_{(vent,\, i)} + \dot{Q}_{(g,\, c,i)} + \dot{Q}_{(cplg,\, i)} \qquad (2)$$

Where,

$\dot{Q}_{i}$: The conductive and convective heat flux

$\dot{Q}_{(surf,i)}$: The convective gains from surfaces

$\dot{Q}_{(inf,i)}$: The infiltration gains

$\dot{Q}_{(vent,\, i)}$: The ventilation gains

$\dot{Q}_{(g,c,i)}$: The internal convective gains

$\dot{Q}_{(cplg,\, i)}$: Gains related to convective air flow

And the radiative heat flows to walls and windows are defined:

$$\dot{Q}_{(r,\, wi)} = \dot{Q}_{(g,\, r,i,\, wi)} + \dot{Q}_{(sol,\, wi)} + \dot{Q}_{(long,\, i)} + \dot{Q}_{(wall\, -gain)} \qquad (3)$$

Where,

$\dot{Q}_{(r,\, wi)}$: The radiative gains for the wall surface temperature node

$\dot{Q}_{(g,\, r,i,\, wi)}$: The radiative air node internal gains received by walls

$\dot{Q}_{(long,\, i)}$: The solar gains through windows received by walls

$\dot{Q}_{(wall\, -gain)}$: Long wave radiation between a wall and others walls and windows

The Figure 4 below shows our project to realize by TRNSys17.

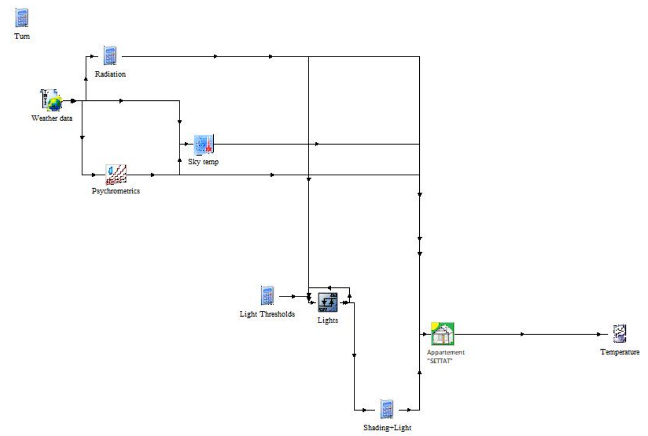


Figure 4: Project simulate with TRNSys17

4. RESULTS AND DISCUSION

In the first phase, we simulated our basic building without taking into account the parameters of the heating and cooling system. Thus we obtained the thermal behavior of this habitat as described in Figure 5 in the form of a graph which presents the temperature of each zone of the building on the annual scale.

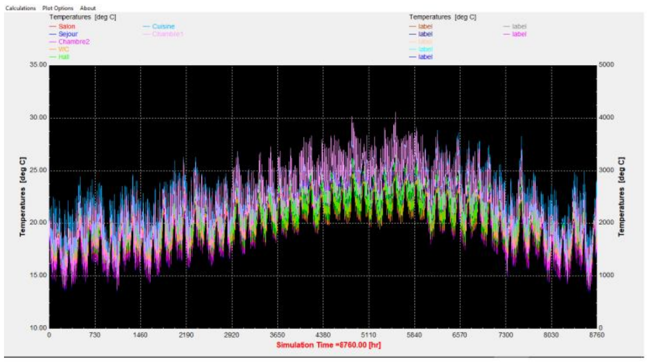


Figure 5: thermal behavior of the building without a heating and cooling system.

According to an analysis of this thermal graph, we see a low temperature which reaches 14 C for the winter period and a high temperature of 30 C in the summer period.

In a second phase, we simulated our building while introducing the parameters of the heating and cooling system with a setpoint of 20 C for the winter period and 26 C for the summer period as recommended by standard NM ISO 7730.

The Figure 6 shows the graph of the building's annual energy consumption, the blue curve describes the consumption without the heating and cooling system while the red curve describes the building's consumption with the heating and cooling system.

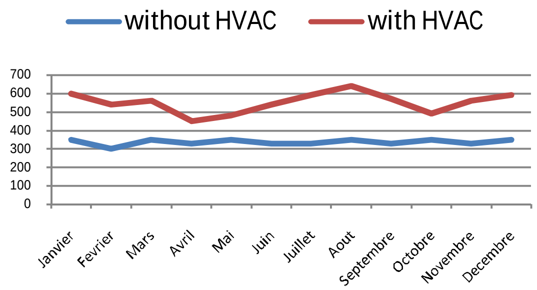


Figure 6: building annual energy consumption

We notice from the graph figure 6 that the normal consumption of the home has almost doubled by using the heating and cooling system while exceeding the threshold recommended by the RTCM.

The following graph Figure 7 presents the energy consumption of heating separately from that of cooling. By calculating the primary power consumption of heating and that of air conditioning Table 5, note the results in the order of energy equality with 10.54 kwh/m2/yr for heating and 12.90 kwh/m2/yr four cooling.

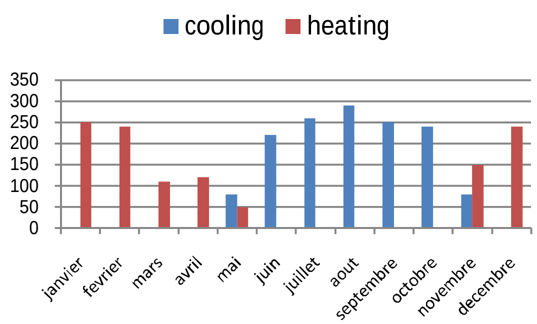


Figure 7: Energy consumption of heating and cooling

Table 5: Total energy consumption of heating and cooling

	Heating ($Kwh/m^2/yr$)	**Cooling ($Kwh/m^2/yr$)**
Power consumption	10,54	12,90

Thus, a comparative analysis was carried out between the results of the simulated electricity consumption with that actually taken from the building's electricity meter for a period of one year (from January 2019 to January 2020). Figure 8 the following graph describes this comparison.

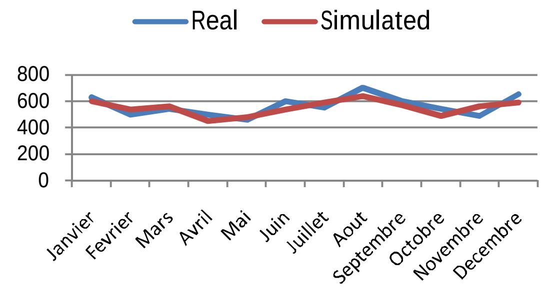


Figure 8: Comparison of the real and simulated consumption

What can be deduced from these results that this observed overconsumption which exceeds the threshold recommended by the RTCM is mainly due to the heating and cooling system, which explains the existence of a correlation between the occupant and the overconsumption, because it always seeks to regulate the temperature of its interior environment in order to create a healthy comfortable habitat, thus its objective is to protect us against bad weather from the external environment.

5. CONCLUSION

In this work, a study was carried out on a reference apartment-type building in order to prove the existence of a correlation between the thermal comfort sought by the occupant and the over-energy consumption of the building. Also to show (by experimentally comparing the results) that this excess consumption is mainly due to the heating and air conditioning system.

Better design based on improving the passive elements of the building can help us create comfortable living conditions while reducing and controlling energy consumption in the building.

And as a prospect for the continuation of this work, the realization of a parametric study of energy retrofits solutions for this building; and this at the level of:

- The choice of the most optimal variant of the envelope of this building.
- Also the choice of the optimal window variant in terms of size and type for this building.

REFERENCES

1. AIE (2012), **World Energy Outlook 2012**, Éditions OCDE, Paris, https://doi.org/10.1787/weo-2012-en.
2. National Authority for Electricity and Drinking Water,**Chiffrescles 2019:** http://www.one.org.ma/FR/pdf/Depliant%20Statistiques%20FR%202019.pdf
3. Agence Nationale d'EfficaciteEnergetique, **La nouvelle stratégie énergétique nationale** :

https://www.amee.ma/sites/default/files/inline-files/LA_NOUVELLE_STRATEGIE_ENERGETIQUE_NATIONALE.pdf
4. ShubhamGhanghas et al., **Design and Development of IoT based Intelligent Home Automation System**, International Journal of Emerging Trends in Engineering Research, 8(7), July 2020, pp. 3487 – 3494 https://doi.org/10.30534/ijeter/2020/98872020
5. MohdAthirKamaruddin et al.,**The Enhancement of Solar Power System Implementation in LAS Building**, International Journal of Emerging Trends in Engineering Research, 8(7), July 2020, pp. 3319 – 3327 https://doi.org/10.30534/ijeter/2020/72872020.
6. Dnyandip K.Bhamare.et al, **Passive cooling techniques for building and their applicability in different climatic zones—the state of art**, Energy and Building, vol. 198, September 2019, pp. 467-490.
7. Centre Scientifique et Technique du Batiment, **Reglesth-u, Determination des caractéristiques thermiques des matériaux**, 2007.
8. RTCM, **Moroccan Thermal Regulation for Construction:** https://www.amee.ma/sites/default/files/inline-files/Reglement_thermique_de_construction_au_Maroc.pdf
9. Meteonorm V7.0.22.8, 2017: www.meteonorrm.com
10. NM ISO 7730, **ergonomics of the thermal-analytical**, Moroccan institute for standardization IMANOR, 2010.
11. TRNSys17, **Transient System Simulation Program**, Solar Energy Labaratory, University of Wisconsin-Madison, USA, 2012.
12. Klein, S.A.; Beckman, W.A.; Mitchell, J.W.; Duffie, J.A.; Duffie, N.A.; Freeman, T.L.; Mitchell, J.C.; Braun, J.E.; Evans, B.L.; Kummer, J.P.; et al. **TRNSYS Version. 17**; Solar Energy Laboratory, University of Wisconsin-Madison: Madison, WI, USA, 2010.