The impact of using thermal insulation and solar energy on the reduction of energy consumption, case of housing in Constantine, Algeria.

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***Abstract*-The purpose of this document is to optimize integrated solutions to the envelope of a building and to combine solar energy with architecture to achieve an optimal level of energy consumption in a collective dwelling. This is done by using materials performance in thermal insulation such as cork, polystyrene, brick, renewable energy, an architectural form that must take into account solar radiation in summer and winter. The objective is to evaluate the evolution of the energy needs according to the energy efficiency measures (BBC case) and the thermal comfort conditions, with geographical coordinates of the basic building correspond to the city of Constantine, in Algeria. The use of the TRNSYS version 16 software was chosen to make the comparison simulations between the two collective dwellings in the city of Constantine. The first is that of a current housing standard case of the city, and the second housing is the optimizing one proposed as project in Constantine city. For a positive and efficient return , where the final goal is to examine the effectiveness of the first compared to the second in terms of energy, economic and environmental.**

***Keywords*-Optimize, BBC, Energy, Constantine, Collective-dwellings.**

I. INTRODUCTION

Today, the consumption of fossil fuels is one of the greatest concerns. Because it is increasing and it has a negative impact on our environment. The main consequences are, air pollution causing an increase in the greenhouse effect that causes global warming. This global warming is likely to lead to a partial melting of the polar ice caps, thus raising sea levels, flooding the lower coastal zones, certain islands and deltas [1]. These data make it necessary to economize and share resources equitably, by using technologies that pollute less, waste less energy, and especially by changing our consumption habits and our behaviors. This is sustainable development. This is not a step backwards, but a step forward for humanity: to consume not less, but better. It has become urgent to act. We have all the means. And above all, the duty [2]. Algeria as a country committed to sustainable development for decades is experiencing intense growth, in the construction and construction sectors, according to APRUE 2015 the residential and tertiary sector in Algeria presents a second strong energy consumption after the transport sector, with a percentage of 36% whose consumption reached 12.8 million PET [3]. The habitat is in Algeria, one of the priorities. Throughout the national territory many achievements are visible. Nevertheless, concerns about thermal comfort and energy efficiency are the normative requirements [4]. It is necessary to be part of an ecological strategy aimed at energy-efficient construction and the reduction of atmospheric pollution. However, the concept of the BBC (bâtiment basse consommation) "low energy building", are new buildings built or rehabilitated have a very low level of energy consumption that does not exceed the threshold of 50 KWh/m²year [5,8,9]. In this study we examine two cases of housing in the city of Constantine, in terms of energy, economic and environmental.

II. METHODOLOGY

The aim of this study is to evaluate the evolution of energy needs according to energy efficiency measures (BBC case) and thermal comfort conditions, with geographical coordinates of the basic building correspond to the city of Constantine.

The use of digital simulation with TRNSYS [7] software for:

• The first is the standard case simulation, which integrates the Algerian standard building specific data in order to simulate the Algerian energy needs.

• The second optimized case simulation (BBC) which consists of applying one-on-one criteria (insulation of the envelope, Install efficient windows, Opt for a high-performance ventilation, dare to use renewable energies ...) to wait for a level of energy consumption less than or equal to 50 KWh/m²year [8,9].

III. PROJECT SITUATION

The BBC case buildings project site is located at the UV5 extension, located in the Ain El BEY Constantine plateau, in Algeria (figure 1).

Fig. 1. Aerial view of the situation, and the ground plan of the BBC buildings [6].

IV. SIMULATION TOOLS

A. Simulation software

There is a large number of software dedicated to energy simulation. Existing software differs between them by the algorithms they use, by their user interface and finally by their vocations and their fields of application.

The software used in this study is: TRNSYS version 16.

TRNSYS software was used for what it is:

-A program performing dynamic simulations

-A program based on a modular approach

-A method to create new models in addition to those of the library of models of thermal systems and auxiliary components (weather data, histograms, ...)

-A solver for solving systems of equations

B. Meteorological data

The meteorological data that should be used for the thermal simulation are by default those of the meteorological station Ain el Bey, Constantine present in the software Meteo 7. Corresponding to the geographical area of the project [10].

In our case, the meteorological data of the basic model are identical in all respects to those of the models of the project:

- Temperature

- Moisture

- The speed and direction of the wind

- Solar radiation

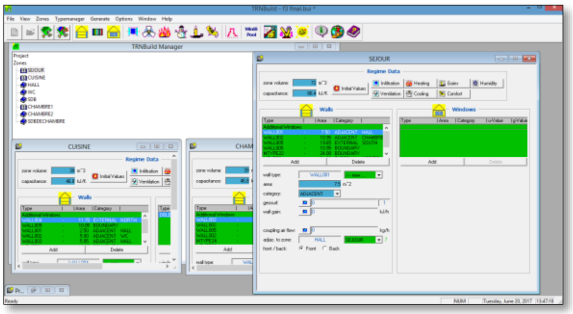

Fig. 6. Modelling the project in TRNBuild

V. SIMULATION STUDY

A. Presentation of the study

The Standard Building taken according to parameters that reflect at most taken the reality of the residential construction promotional in Algeria. The housing has a surface of 120m^2, and volume of 360m3.

The second building is optimization (energy-based), F3 is 120 m² and 360 m3 in volume at the new city of Ali Mendjli in Constantine.

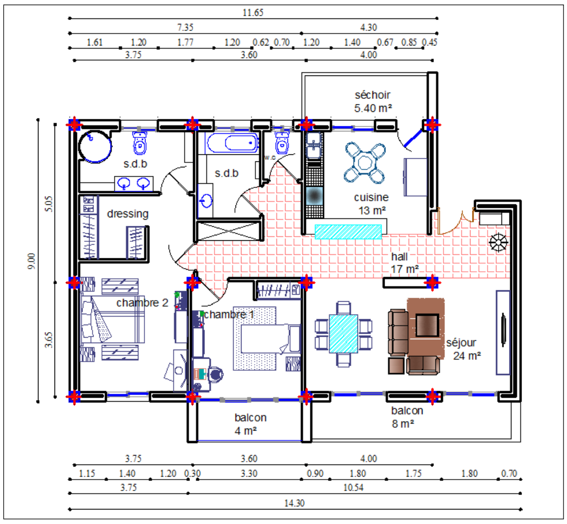

Fig. 2. simulation case plan (BBC)

The rooms: living room and bedrooms are facing south as shown in the figure below. The north exterior walls are insulated with a thickness of 35cm; the others have a thickness of 30 cm, while the separations are hollow brick of 10 cm the coating and the plaster are on both sides.

The low floor is type 24 in TRNSYS consists of a layer BA 13 1.3cm, hourdis-polystyrene 16cm, concrete of a thickness of 4cm followed by 2cm of cork and tile 2cm (the undercoat is cement mortar d a thickness of 3cm). The vegetable roof consists of a layer of BA 13 1.3cm, hourdis-polystyrene 16cm, concrete of a thickness of 10cm, poly-ext of 4cm, vapor barrier, cork of 3cm, layer resistant to the penetration of roots, a filter for drainage, and the 10 cm plant layer.

The figures below (figure 3,4,5) define the composition of the walls.

Fig. 3. North wall composition, slab composition and composition of south, east and west wall.

VI. ENERGY EFFICIENCY MEASURES TO STUDY

A. Types of windows

The study of the influence of the type of windows on energy needs.

Table 1. Characteristics of windows [11,12].

WINDOW	coefficient of loss U (W/m²k)	coefficient of transmission g (%)	Height (m)	Width (m)
Single glazing	5.74	87.00	1.00	0.80
Double glazing	2.95	77.70	1.00	0.80
Triple glazing	2.00	70.00	1.00	0.80
Double glazing low emissive	1.76	59.70	1.00	0.80

B. Types of building materials

The simulation will be on the relevance of the choice of materials of the external facades, so we will retain four types of materials in addition to our case which is built in hollow brick, concrete, BA13, plaster, as well as two composition: Double wall with a thickness of 35 cm as shown in the figure below. The choice of thicknesses of materials is motivated by their availability on the Algerian market in this form.

C. The impact of insulation

The impact of insulation will be at the heart of this simulation, in fact we have opted for expanded polystyrene and expanded cork and BA13 as insulators for conventional materials whose thermal characteristics are:

Polystyrene: $\lambda = 0.141$ (KJ/hmK), $C = 1.38$ (KJ/kgK) and $d = 25$ (kg / m^3).

Cork: $\lambda = 0.14$ (KJ/hmK), $C = 0.48$ (KJ/kgK) and $d = 120$ (kg / m^3).

BA13: $\lambda = 1.16$ (KJ/hmK), $C = 0.8$ (KJ/kgK) and $d = 790$ (kg / m^3).

The insulation will be used in several thicknesses that vary between 1 *cm* and 16 *cm*, for exterior facades, roofing and low floor; in order to determine both which part to isolate in priority and the thickness of the insulation that guarantees an optimal energy requirement.

D. Solar energy

For the production of solar energy in the case of the BBC one has to opt for the use of the technology of Rawlemon created by the German architect André Broessel which has the advantage of working day and night, a Rawlemon βray 1.0 2.15m * 1.30m * 1.80m and depending on the region of Constantine and meteorological data, we have an electricity production of 241.9 kwh / year [13,14].

Fig. 4. Rawlemon the solar energy generator [13,14].

VII. PROJECT MODELING ON STUDIO SIMULATION

The project was modilized on the interface of the simulation studio tool as the first phase in the study process.

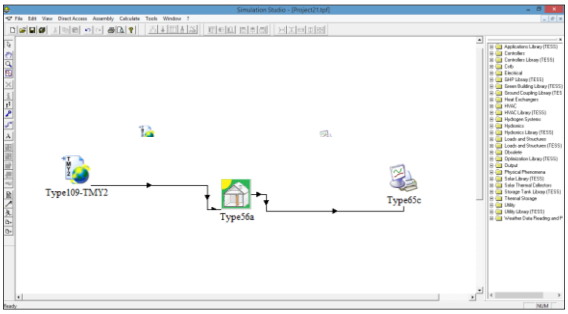

Fig. 5. Project modeling in studio simulation.

A. Results and discussion

A.A. Standard case (without insulation, type of single glazing, standard materials)

The simulation of the standard case gave an annual energy requirement of 29701 (KWh) 105.16 KWh/m²year.

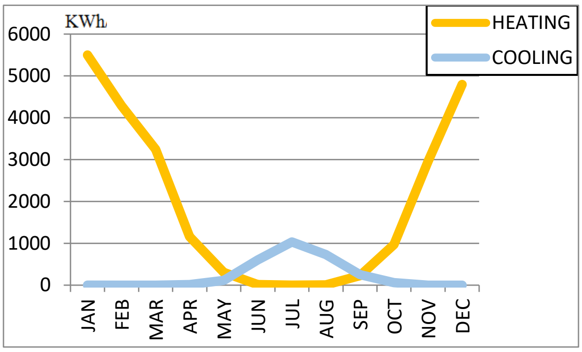

Fig. 6. Energy need in heating and cooling of the standard case

Table 2. Result of the standard case.

MONTH	HEATING	COOLING	SOLAR_RAD.	INT_GAINS
-	[KWH]	[KWH]	[KWH]	[KWH]
JAN	5500	0.00	1323	491.0
FEB	4289	0.2131	1504	443.5
MAR	3241	1.433	1454	491.0
APR	1161	12.41	1222	475.2
MAY	303.4	112.8	1221	4910
JUN	16.17	602.9	1144	475.2
JUL	0.00	1032	1187	491.0
AUG	3.515	732.3	1386	491.0
SEP	224.2	252.8	1383	475.2
OCT	965.9	56.42	1479	491.0
NOV	2965	1.148	1189	475.2
DEC	4792	0.1619	1253	491.0
SUM	23460	2804	15750	5782
TOTAL KWh/m²year	26264+(3437 of ligt / hot water)			
TOTAL KWh/m²year	105.16			

A.B. BBC case (With insulation, type of AG double glazing, materials covered)

The simulation of the low-energy building case gave an annual energy requirement of 5732.00 (KWh) 47.8 KWh/m²year.

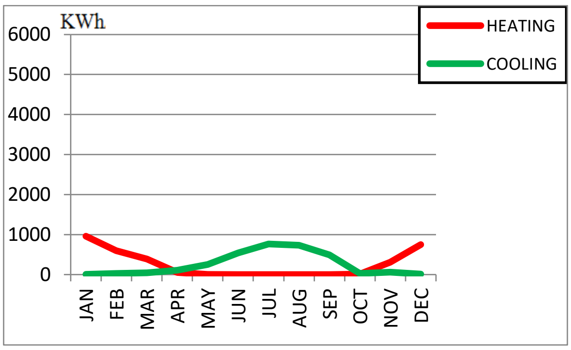

Fig. 7. Energy need in heating and cooling case of BBC

Table 3. BBC Case Result

MONTH	HEATING	COOLING	SOLAR_RAD.	INT_GAINS
-	[KWH]	[KWH]	[KWH]	[KWH]
JAN	958.8	5.889	805.5	491.0
FEB	595.1	27.53	900.3	443.5
MAR	390.7	40.66	852.0	491.0
APR	49.01	105.3	697.4	475.2
MAY	0.2309	253.6	682.7	491.0
JUN	0.00	540.9	638.5	475.2
JUL	0.00	764.5	659.5	491.0
AUG	0.00	732.2	779.6	491.0
SEP	0.00	491.2	800.2	475.2
OCT	8.761	29.18	878.8	491.0
NOV	311.5	63.77	720.3	475.2
DEC	747.6	15.69	764.0	491.0
SUM	3062	3333	9179	5782
TOTAL KWH	6395/2.86=2236.01			
Lamp (LED) 12w/h	163.52			
hot water kwh	660			
Consumption KWh/m²year	65.26			
Reduction with rawlemon βray 1.0 kwh/year	241.9			
TOTAL en KWh/m²year	43.75			

VIII. COMPARISON OF THE TWO CASES

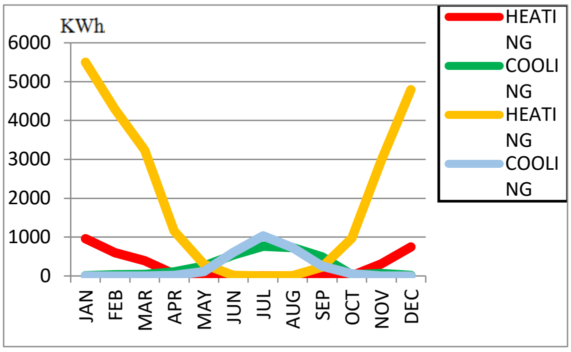

Fig. 8. Comparison of energy needs in heating and air conditioning.

Note that the energy requirements are reduced from 29701 (KWh) 105.16 KWh/m²year (standard case) up to 3059.53 (KWh) 43.75 KWh/m²year for the case of the building with low consumption. So we see that there is a 42% reduction compared to the total annual energy requirement. The figure 9 shows the comparison between sectors from where the standard case represents 71% as well as the case of the BBC presents a high efficiency with 29%.

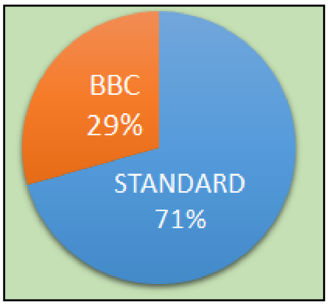

Fig. 9. Comparison of the two cases.

A. Types of windows

The low-emission AR double-glazed window will be retained as the optimal case in this simulation stage, this type of glazing has brought a substantial gain.

B. Glass surfaces

The study of the impact of the distribution of the percentage of glazed surfaces in each facade aims to examine the energy gain in heating thanks to solar contributions.

The first simulation kept single-pane windows in the base case that have a high coefficient of heat loss (5.74 W / m^2 K), which led to the simulation of energy needs being insensitive to energy gains by modifying the proportion of glazed areas, for all facades including the south facade.

The double glazing windows were at the centre of the second simulation, the south facade, the gain is greater.

The determination of the proportion of glazed areas for each facade can not be defined at this stage, because the integration of solar protection which aims to lower the need for air conditioning and increase that of heating contrary to the increase in the glazed surface, the integration of these two factors produces the optimal case.

C. Type of construction materials

The breeze block (one of the most used materials) has a dismal energy performance unlike the double hollow brick wall that has an energy gain of 21.92%.

The details of the results show that the first result must be nuanced. Indeed we must integrate other parameters that must be kept separately: the needs for air conditioning and heating. Knowing that the final energy for air conditioning is much more important.

The hollow brick will be retained as the optimal case in this simulation stage.

D. The impact of insulation

The results showed that the low floor insulation had a negative impact on the total energy gain, while the insulation of the roof and the external walls have a significant impact although in different proportions.

The insulation of the external walls can bring a significant gain, but the insulation of the roof largely exceeds those of the external walls, in addition the insulation of the roof allowed a reduction of the energy requirement in heating and air conditioning simultaneously contrary to the external wall insulation that lowers only the need for heating.

IX. CONCLUSION

The residential sector is the one whose attention in terms of energy efficiency should be turned, being everywhere the sector responsible for most of the energy consumption, this is all the more true for Algeria.

For a better result we must think of the insulation of the opaque walls and glazed.

The most economically justified measure for the reduction of energy consumption is the insulation of the roof associated with an insulation of the envelope and the use of the low emission double glazing AG.

The insulation acts as a thermal barrier, preventing the heat flow into the room during the summer period and outward during the winter period.

The main facade with large openings (equipped with mobile sunshade for summer comfort) is facing south, to benefit from solar heating and protection in summer, while the other facades have smaller openings to prevent wastage .

X. RECOMMENDATION

Applications to ensure annual energy consumption below 50 kWh / m^2 year

• North outside wall of 35 cm with insulation (brick 15 cm, cork 3cm, polystyrene 5cm and brick 10cm) figure 32: composition wall North.

• Exterior wall south, east, west of 30 cm with insulation (brick 15cm, polystyrene 5cm, brick 10cm).

• Vegetable roof: made of BA 13 1.3cm layer, hourdi-polystyrene 16cm, 10 d'thick concrete, 4cm poly-ext, vapor barrier, 3cm cork, resistant to root penetration layer, filter for drainage, and the plant layer of 10 cm.

• Orientation of spaces according to occupant activity (south).

• The low emissivity double glazed window, Argon u = 1.43 g = 0.59.

• Mobile solar protection according to the need of interior comfort.

• The use of efficient solar technologies, such as Rawlemon.

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