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Enhance the Efficiency of the Facades Existing Higher Education Buildings in the Cairo Region

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ABSTRACT: With the advent of modern technology in building materials, which made it not only dependent on the role of thickness in raising the efficiency of the insulating material, but instead on changing the state of the material from one state to another, and other technologies, interest in those materials and the study of thermal properties and methods of applying them to simulation programs is necessary, as well as the calculation of the savings rate. The application of traditional and high-performance insulation materials is an essential issue in the World. Also, the group of materials of a unique nature to work on walls helps to raise the efficiency of the facade of higher education buildings in Egypt, and these materials do not depend on thermal resistance.

The research focuses on evaluating the energy performance of the model. Window walls (WWR 30%) represent most of the private higher education buildings in Cairo, which consume a large percentage of energy as most of them are centrally air-conditioned buildings.

The modelling of the learning space was carried out using the Design-Builder program, by adopting the climate of Greater Cairo, testing a set of proposals, and directing materials for these materials in modifying the outer walls of the facade that has the most massive heat load and that was the southwestern facade and reaching a set of solutions. The best of them was the polystyrene material which achieves the best resistance. Thermal resistance within a group of resistance proposals and their impact on energy saving, energy saving of 7.5% at 1.8m²-k / watt thermal resistance with a thickness of 39 mm. Among the high-performance insulation materials, the material was filled with gas, which achieved 7.8% saving and the best-advanced material effect was that the phase change material had the best effect because it saved 10.8% and better cost on wall modification.

KEYWORDS: Retrofit, Thermal resistance, Traditional insulation materials, High-performance insulation material, Energy efficiency.

I. INTRODUCTION

In recent years, temperatures have risen dramatically and become a defining problem of the importance of thermal insulation in buildings, whether they are already in place or still under construction. The construction sector has made tremendous development in the field of building materials, including brick in walls that are easy to operate.

However, the owner of this material has some disadvantages regarding their properties. The bricks have good heat conductivity and quick loss, which makes their use in building construction without insulation or conditioning uncomfortable for humans.

Most of the university educational buildings located in Cairo have walls of hollow concrete bricks because of the field survey of the buildings. Therefore, it is necessary to use traditional insulation materials or high-performance materials that can provide thermal comfort to the building with the least possible use of air conditioning.

Although the walls are not the primary element in determining the energy performance, if solar radiation enters through them, it will be high and have a precise effect, so work has been done on the climatic conditions in the Greater Cairo area, and the study includes the application of a group of traditional insulation materials and materials. High performance and a group of materials that have other physical properties that do not entirely depend on the thermal resistance on the wall and study the extent of energy saving when placed on the outer wall of the facade.

According to the Intergovernmental Panel on Climate Change, Egypt is among those countries that will be most affected by the impact of climate change, even though greenhouse gas emissions (GHG) represent only 1% of global greenhouse gas emissions [1]. Existing buildings contribute to an increase in energy consumption compared to new buildings due to their inefficiency and the almost complete lack of implementation of sustainability, and energy-saving measures [2] The energy used in buildings to operate their systems required to ensure the comfort of the building's

occupants; Such as cooling, heating and ventilation which all consume more than 40% of the total energy, and the rest is used for lighting, elevators, equipment... etc. [3] In Cairo, Egypt, existing buildings are the primary consumers of electrical energy, which is approximately 86% [4]. Hence, improving existing buildings is as vital for urban climate action as improving energy efficiency in a new building [5].

II. RELATED WORK

Each type of insulation has its advantages and disadvantages that must be considered. Even though any insulation can be applied in the wall; some of them are more suitable for the wall than others. The types of insulation used in the wall are usually divided into three categories, described below [6].

These categories classify insulating materials into **traditional insulation wall** and **advanced insulation wall (Innovative materials) and Techniques on the wall**.

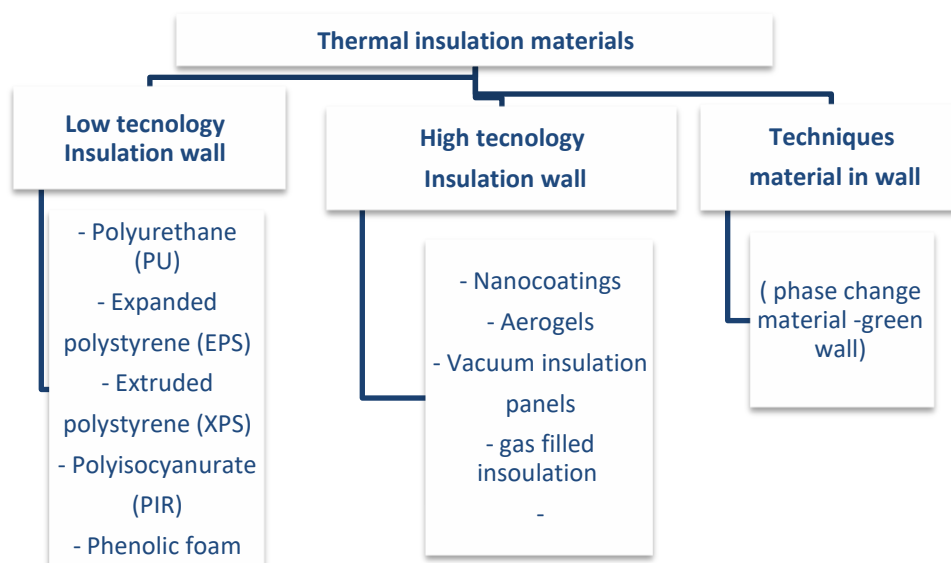


Figure (a) types of materials used in thermal insulation of buildings
Source: (by a researcher)

Insulation materials currently dominate the most critical market opportunity of such products in construction applications, offering the most excellent performance per unit cost, such as plastic foams derived from organic fossil fuels such as (polyurethane, polystyrene) and mineral wool (glass, stone) [7].

Using materials with high thermal properties in the building energy retrofitting process can have extensive effects and outcomes on the energy performance in the building [8].

Improving the building envelope energy efficiency and renewable energy integration, function by giving advanced materials with fixed or dynamic high performance the opportunity to counterbalance performance requirements within the confined architectural limits and artistic requirements [9]. Advanced insulating materials (Fiber Reinforced Aerogel Blankets, Vacuum Insulated Panels) with extremely reduced thickness provide architectural integration, minimalistic obstruction approaches, curtailing thermal bridges any piping application. There are different methods of a resembling nature when it comes to their characteristics and components; this, in turn, leads to various achieved results and levels to the same aim. ; Phase Change Materials (PCMs) raise thermal inertia of the envelope or interior division; this works by allowing passive solar heating to create thermal heat storage, this particularly advantageous as it does not add any additional weight or mass. The second method is, by using Reflective Coatings that work well in two opposed directions, either by increasing thermal insulation or the other direction, which is reducing the overload of solar radiation.

III. METHODOLOGY

To achieve the goal of this research, the following methodology was used:

□ Create suitable comfort conditions

To determine the appropriate retrofit procedures, the current performance of the model in terms of operation, schedule and climate must be evaluated in the existing model to simulate reality. Therefore, the data collection step must come first.

Conduct a field survey to:

- (1) Determine the description and construction materials.
- (2) Perform a dynamic simulation of the base case
- (5) Comparison of simulation estimates for modified case and base case.

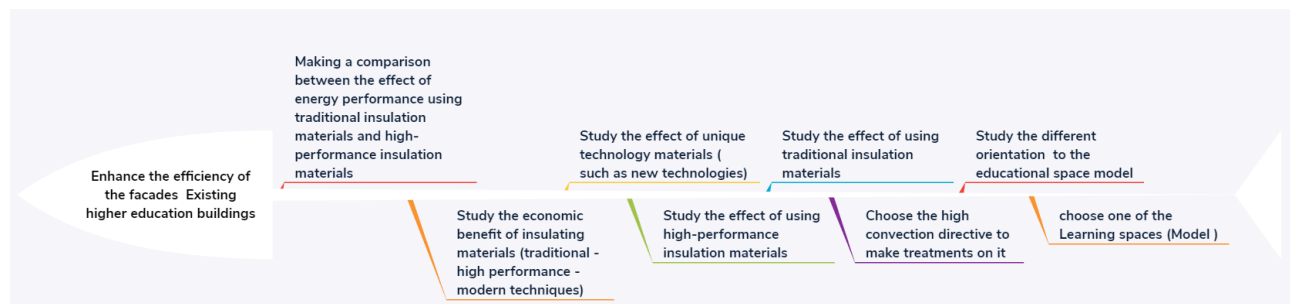


Figure (a) types of materials used in thermal insulation of buildings

Source: (by a researcher)

The research will propose some changes to the building's western south façade by integrating traditional insulation materials and internationally advanced high-efficiency materials and applying them to the modular façade (educational space) to modify the energy performance of the building, thus reducing energy consumption to a minimum. Using Design-Builder energy simulation software will deduce the energy saved by retrofit procedures. It can be compared with current values to verify the proposed methodology and achieve the objective stated in this paper.

The proposed methodology for the rehabilitation of the existing higher education buildings and the identification and implementation of the best retrofit methods to achieve the best solution for improving energy efficiency in the existing higher education buildings in Egypt. The retrofit strategy consists of three parts:

The research proposes to use the higher education unit (learning space) with an area of 96 square meters as a measurement model for research ideas as a model experiment to reach energy availability in the case of (WWR30%) on the southwestern façade.

A. Primary treatment

It requires a survey before retrofitting to understand better the building's operational issues and the significant concerns of the building's occupants. This stage also includes the evaluation of energy performance. This assessment aims to understand energy use in buildings to find appropriate solutions.

B. Design decision analysis

At this stage, several modified alternative solutions that can reduce energy consumption must be identified and created. Then evaluate the performance of retrofit alternatives by simulating this alternative analysis, energy consumption, and cost analysis.

C- Determine the possible design alternatives.

Most of the time, it is not easy to choose one alternative as the best alternative because the alternatives compete across multiple goals.

Decision-makers choose the best alternative interface solutions to the performance problem (maximum energy saving or lowest cost) according to the users.

The methodology steps will guide architects and decision-makers in directing productive information from the simulations to select the optimal solutions according to their needs. The optimum solution can be chosen based on informed and accurate evaluation decisions such as maximum energy savings or the lowest cost.



IV. EXPERIMENTAL RESULTS

Figure (b,c) shows the annual energy demand for base case cooling before any technologies are applied. The cooling requirements were calculated using two specific points 26 ° C and 20 ° C respectively, according to ISO 7730. For the city of Cairo, the annual cooling demand reached its peak at the western façade of 3535 kWh in the case of WWR 30%.

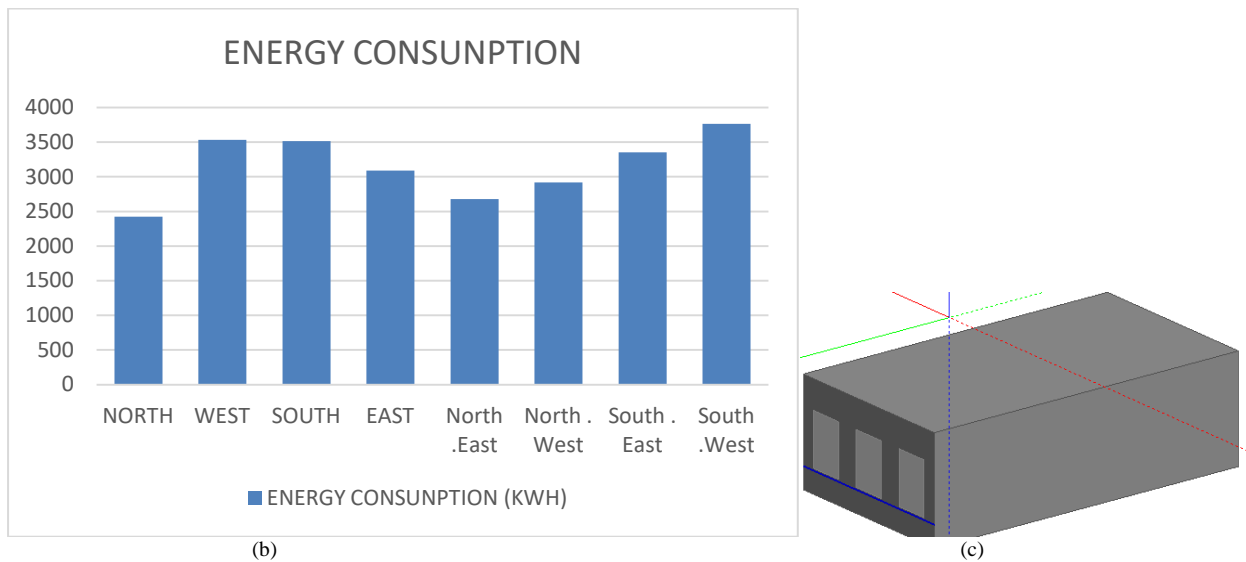
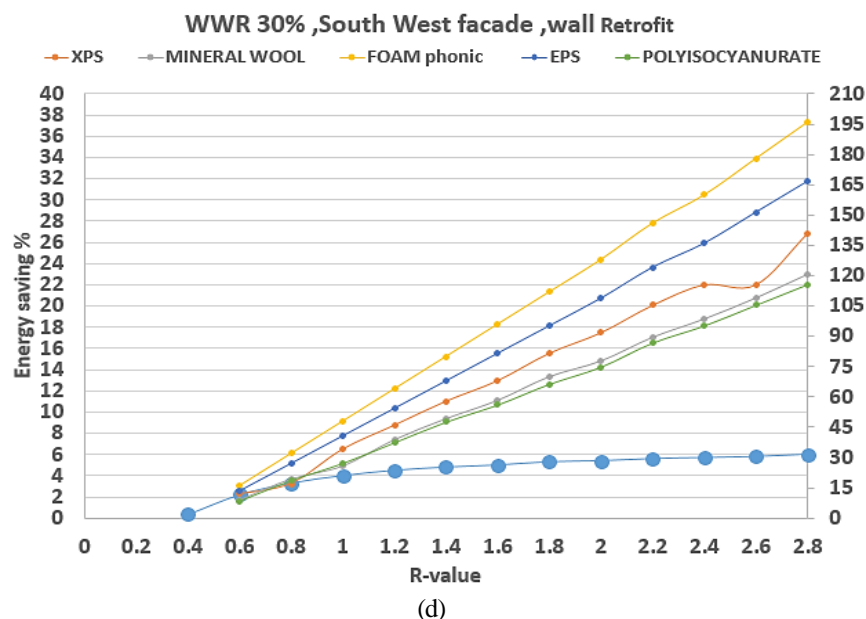


Figure (d) : the relationship of the proposed resistance values to the energy savings compared to the cost of the thickness required to reach these savings in insulation materials in the local market in Southwest orientation.

The thermal resistance proposals of the outer wall (0.4-8.2) (M²-K / W to WWR 30% in the northeast direction, it was observed that the energy-saving was 4.5% with a resistance value of 1.2 (M²-K / W), and after So the improvement began to drop and almost constant way, with increasing thickness and costs, the saving rate was not great, which means that this value is the best value that can be used on the south-west façade and when using the materials available in the local market if the best material is polystyrene foam as it is less thick and less expensive As its thickness is 23 mm for 37.4 EGP- this depends on the thermal conductivity of the material and thus the thickness

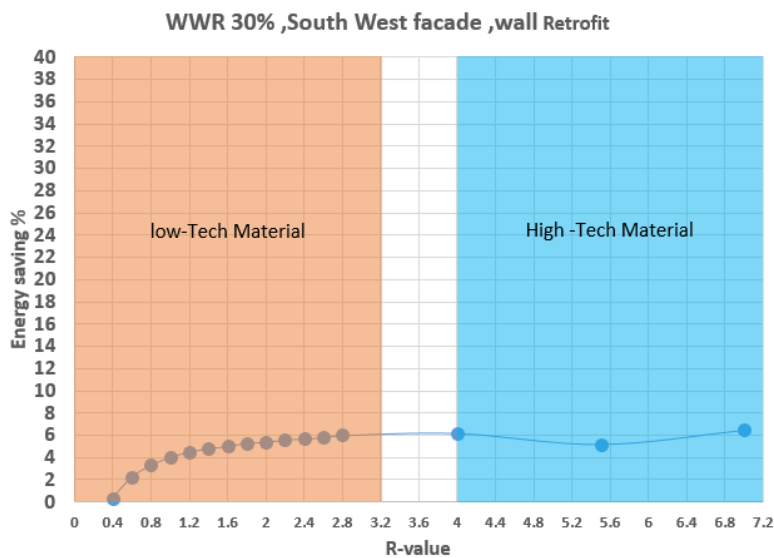




ORINTHTION		R-VALUE (M2-K/W)	U-VALUE (W-M2-K)	ENERGY CONSUMPTION (KWH)	ENERGY SAVING (%)	Material eProposal															
U-value of existing building (high education) 2.6(W-M2-K) R-VALUE =0.37(M2-K/W)						EPS	POLYSTYRENE	FOAM phonic	MINERAL WOOL	XPS											
WWR 30%		0.4	2.5	3753	0.34	0.2	0.1	0.2	0.2	0.1											
ENERGY CONSUMPTION		3766K				8	5	8.5	8	16	7	9.1	7	11.9							
South. West		0.6	1.66	3681	2.2	13.6	11	18.7	16	32	15	19.5	10	17							
		0.8	1.25	3641	3.3	16	27.2	16	27.2	24	48	20	26	20	34						
		1	1	3615	4	24	40.8	16	27.2	24	48	20	26	20	34						
		1.2	0.83	3597	4.5	32	54.4	22	37.4	32	64	30	39	27	45.9						
		1.4	0.71	3584	4.8	40	68	28	47.6	40	80	38	49.4	34	57.8						
		1.6	0.625	3574	5	48	81.6	33	56.1	48	96	45	58.5	40	68						
		1.8	0.55	3565	5.3	56	95.2	39	66.3	56	112	54	70.2	48	81.6						
		2	0.5	3560	5.4	64	108.8	44	74.4	64	128	60	78	54	91.8						
		2.2	0.45	3553	5.6	73	124.1	51	86.7	73	146	69	89.7	62	105						
		2.4	0.416	3549	5.7	80	136	56	95.2	80	160	76	98.8	68	116						
	2.6	0.38	3544	5.8	89	151.3	62	105.4	89	178	84	109	68	116							
	2.8	0.35	3540	6	98	166.6	68	115.6	98	196	93	121	83	141							

Table (a): shows all the R-values proposed in the Southwestern façade and U- values of the energy savings compare the base case if a retrofit is used to reach this peak and the thickness of each insulation material and its cost from the materials in the local market.

Figure (f): A comparison between low-tech and high-tech materials, showing a comparison of the thermal resistance values that can be achieved from conventional materials. On the other hand, by using high-performance insulation materials, we observe a specific range of thermal resistance more significant than traditional insulation materials. With less thickness, despite the high cost, the advanced use of aerogel blanket has 5.3 thermal resistance (M2-K / W). Against a 5.2% saving. However, we note energy savings through the use of vacuum insulation with a thermal resistance of 7 (M2-K / W) which is a vacuum insulation plate that provides about 6.5%, with a thickness of 20 mm each, but is filled with gas. The cost of insulation is about 80 EGP, and we note that the saving between them is not high concerning the price, it saves 6.2% of energy.



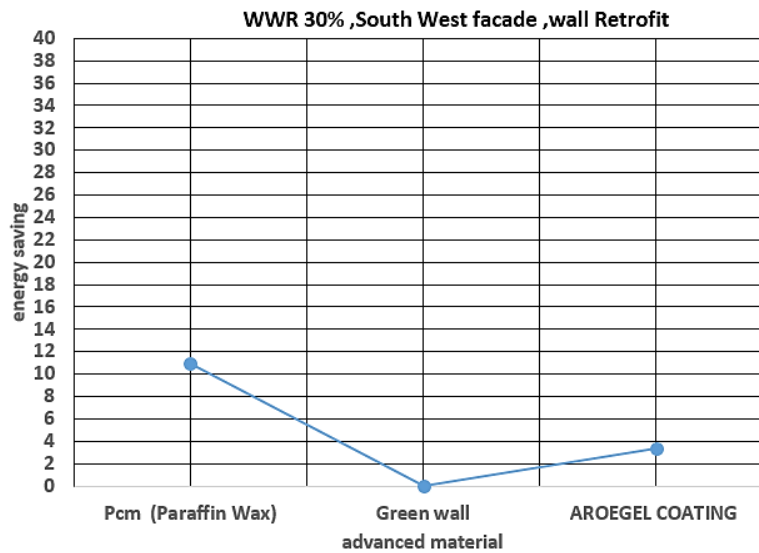
(f)

Table (b) : It shows the values of high-performance insulation materials and their energy savings at 20 mm thickness in south West orientation



ORIENTATION	South .West						
	R-VALUE (M2-K/W)	U-VALUE (W-M2-K)	THERMAL CONDUCTIVITY (W/M-K)	THICKNESS (MM)	ENERGY CONSUMPTION (KWH)	ENERGY SAVING (%)	COST Egyptian Pound
3766 KWH							
VIP(VACUM INSULATION)	7	0.14	0.003	20 MM	3519	6.5	288
GAS FILLED INSULATION	4	0.24	0.005	20 MM	3532	6.2	80
AROGEL INSULATION	5.3	0.18	0.004	20 MM	3570	5.2	240

Figure (g): shows the material of phase change material (PCM), green wall and aerogel coating, and the percentage of energy savings when used on the East facade in the case of WWR 30 %



(g)

The table(c) The table: shows each of the values of the resistance and the physical properties of each material and its thickness and cost of achieving this and saving of south-west facade energy when achieving retrofit on the thickness

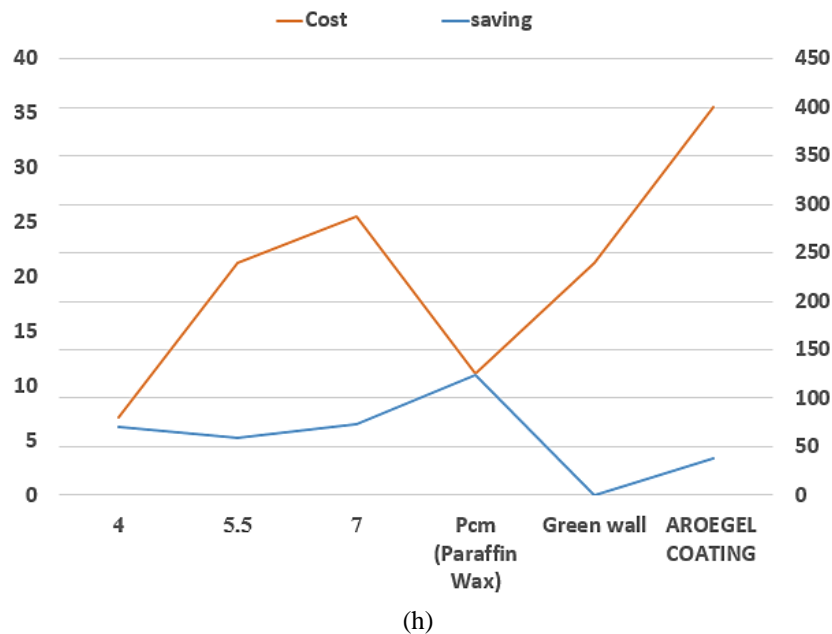
When using a phase change material (PCM) inside the wall, it saves 11% when it is 20 mm thick at the cost of 125 EGP, And by applying a 4 mm thick aerogel coating material, it saves 4.3% Energy is at the cost of 400EGP, so we find that the best of them in terms of energy savings is the use of PCM, but in terms of cost and savings, in this orientation from the façade.

ORIENTATION ENERGY CONSPITION OF BASE CASE=3766	South .West						
	R-VALUE (M2-K/W)	U-VALUE (W-M2-K)	THERMAL CONDUCTIVITY (W/M-K)	THICKNESS (MM)	ENERGY CONSUMPTION (KWH)	ENERGY SAVING (%)	COST Egyptian Pound
Green wall	0.55	1.79	0.3	55	8154	REFUSED	240
Pcm (Paraffin Wax)	0.5	1.9	0.22	20mm	3347	11	125
Aerogel coating	0.6	1.5	0.015	4	3604	4.3	400

Table (c)

Fig (h): The figure shows a comparison between the cost and the savings in high-performance materials, whether they are insulation materials or materials of a unique nature in their effect on the wall of south West orientation

when using advanced materials with a thickness of 20 mm, we find that the energy saving is close to each other in its value, but the best effect and cost compared to the rest of the materials is the phase change material. When choosing a more economical material, it is less expensive, as its cost is 125 GEP and provides 11%. The second option is gas-filled insulation, as its cost is 80 GEP and saves 6.2%.



V. CONCLUSION

By auditing the energy in the building envelope, the critical energy factors are identified, and thus improvements that could be made in the energy simulation program are applied for the evaluation. Use of external wall insulation (polystyrene) from conventional insulation materials; It was one of the best insulation materials in terms of cost and thickness, as the best thickness of 22 mm cost 37.4 g. It can be added to an existing wall façade to improve u value; As for the high-performance materials that can be used in the wall, it was (gas-filled insulation costing 80EGP or PCM at the cost of 125EGP) and with a thickness of 20 mm each.

REFERENCES

- [1] GOLDSON, A. P., et al. Accelerating low carbon development in the World's cities. 2015.
- [2] ABOULNAGA, Mohsen, et al. Sustainability of Higher Educational Buildings: Retrofitting Measures to Enhance Energy Performance—The Case of AASTMT Business Management School Building, Egypt. In: Mediterranean Green Buildings & Renewable Energy. Springer, Cham, p. 117-150, 2017.
- [3] RHOADS, J. Low carbon retrofit toolkit-A roadmap to success. Available online: <http://climatechangeecon.Org/index.Php>, 2010.
- [4] MA, Zhenjun, et al. Existing building retrofits: Methodology and state-of-the-art. Energy and Buildings, 55, P. 889-902, 2012.
- [5] MA, Zhenjun, et al. Existing building retrofits: Methodology and state-of-the-art. Energy and Buildings, 55, P. 889-902, 2012.
- [6] ADITYA, Lisa, et al. A review on insulation materials for energy conservation in buildings. *Renewable and sustainable energy reviews*, P. 1352-1365, 2017.
- [7] MORSY, M., et al. Effect of thermal insulation on building thermal comfort and energy consumption in Egypt. Journal of Advanced Research in Applied Mechanics, P. 8-19, 2018.
- [8] BARTON, R., et al. Retrofitting in Educational Buildings-Energy Concept Adviser for Technical Retrofit Measures. Technical Synthesis Report Annex, P. 36, 2007
- [9] ADITYA, Lisa, et al. A review on insulation materials for energy conservation in buildings. *Renewable and sustainable energy reviews*, P. 1352-1365, 2017.



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