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PROMOTING GREEN RETROFITTING TO ENHANCE ENERGY EFFICIENCY OF RESIDENTIAL BUILDINGS IN EGYPT

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ABSTRACT

This paper attempts to formulate a guideline to the actions required to promote green retrofitting in the Egyptian residential sector. Buildings play a primary role in any national economy, yet they also contribute significantly to global energy consumption. The existing building stock remains a challenging and crucial part of the equation. Achieving sustainability in the existing building stock is particularly challenging in a country like Egypt, as it faced a severe power crisis in the past few years. The residential sector, in particular, is responsible for around 51% of the country's power consumption. The paper starts by introducing the concept of green retrofitting and highlighting the benefits of adopting such an approach. International case studies are reviewed to highlight possible energy savings benefits of applying green retrofitting. A local case study is analysed using the hourly analysis program revealing considerable induced energy savings. The paper concludes by recommending the actions required to promote green retrofitting in the Egyptian market while addressing the roles and responsibilities of the different stakeholders, building upon a more holistic approach to achieving sustainability in the building sector in the long run.

KEYWORDS: Retrofitting, Residential buildings, Energy savings, Existing buildings.

1. INTRODUCTION

Many developed countries focus on finding effective methods to reduce the carbon footprint and increase energy savings of the building sector as a whole. This led many countries to consider more sustainable approaches for new developments and new projects. However, dealing with new buildings alone will not contribute significantly to the carbon emissions reduction, or in increasing the energy savings of the building stock. Accordingly, the focus should also include the existing building stock. This would play a significant role in improving energy savings in the building sector, and hence increase

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the energy efficiency [1]. There are potentially considerable impacts in terms of energy savings through robust, accurate, and cost-effective retrofit activities for existing buildings [2-4]. It was reported that greening existing buildings contributes to global warming reduction, as about 40-60% savings in energy can be achieved in existing buildings [5, 6]. However, it is important to identify the right plan for retrofitting existing buildings as the upfront investment cost is considerably high [7]. This is also the case in a city like Cairo, Egypt, where the existing building stock is very condensed and should be adequately investigated for retrofitting in order to guarantee a proper improvement in terms of energy saving. In Egypt, the residential sector alone is responsible for around 51% of the country's electricity consumption [8]. While the implementation of green measures is still in the early stages and a detailed framework to promote it is necessary [9]. Owing to the hot Egyptian climate, retrofitting in existing buildings has been reported to decrease energy use of buildings, with clear energy savings [6-10]. This is particularly essential after the country faced a power crisis in recent years, and the crisis could hence persist if not properly addressed. However, most studies of green retrofitting conducted in Egypt were aimed at commercial and educational buildings [6-10]. The focus of this research, therefore, is on residential buildings since this sector is considered as a high energy consumer. The paper will attempt to highlight the role of green retrofitting in enhancing the performance of residential buildings and illustrates that its implementation would result in clear energy savings.

2. METHODOLOGY

The research will start with a literature review to introduce the concept of green retrofitting and highlight its benefits and the obstacles facing its promotion. The review will also cover international case studies in which energy saving occurred when green retrofitting was applied to residential buildings. Only two of the approaches recommended for retrofitting will be investigated, namely, deep energy (the envelope approach) and conventional energy (indoor intervention). A local case study will be thoroughly analysed using the commercially available Hourly Analysis Program (HAP) to determine energy savings quantitatively. The research will conclude with the recommendation of actions required locally to promote green retrofitting while identifying the roles of different involved stakeholders.

3. GREEN RETROFITTING

The U.S. Green Building Council defines green retrofitting as any upgrade to an existing building to improve energy efficiency, reduce water use, and improve the comfort and quality of the place. The building should inevitably be maintained to sustain its low environmental impact on the long run [11]. Other definitions introduce green retrofitting as a system intervention in order to improve the energy efficiency of the building and optimize its energy performance [5-7]. Buildings are recognised as being key energy consumers and emitters since they are responsible for up to 36% of global energy use [12]. Green retrofitting of existing buildings is one of the effective ways to save energy and reduce CO_2 emissions [2-4]. Currently, in Europe alone, there are about 200 million buildings, and the majority of them do not live up to current building standards while less than two million new buildings are constructed every year. Accordingly, "the greatest potential for energy and CO_2 gains lies in existing buildings [13]". Many countries have set a target to reduce their carbon footprints and increase energy efficiency, especially in buildings by the year 2050. It is estimated that by 2050, approximately 80 % of all buildings will be currently existing constructions, which is why retrofitting is so important to achieve this goal [14]. Retrofitting of buildings in either the residential or commercial sectors, to increase energy savings can include either full renovations or simple low costs solutions. Figure 1 shows that in Egypt, the residential sector is the highest consumer of electricity. Accordingly, retrofitting is necessary in order to save energy in this sector, since it is as an efficient method to increase energy efficiency of buildings [15].

Owing to the technical and structural aspects associated with retrofitting operations they should be undertaken by specialists. It is therefore essential to have regulations governing the implementation of retrofitting operations. These could be in the form of operation manuals or a building code [17].

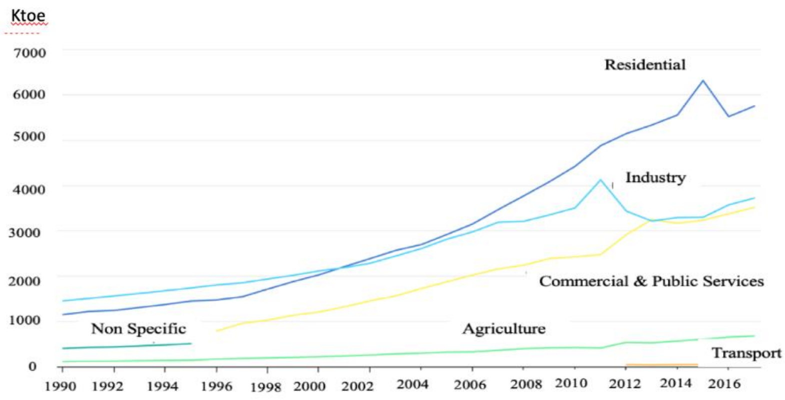

Fig. 1. Electricity consumption by sector, Egypt 1990-2017 [16].

3.1 Benefits of Green Retrofitting

The following points summarize some of the main benefits of green retrofitting [18].

- Reduce energy consumption, save energy, and reduce electricity bills.
- Improve comfort in homes by providing better indoor environmental quality.
- Increase thermal comfort and improving the health of the building's occupants.
- Mitigate climate change through improved energy efficiency, reduce carbon dioxide emissions, and improve resistance to more frequent extreme weather conditions.
- Increase the market value of a building while extending its lifetime and generate job opportunities.

3.2 Barriers to Green Retrofitting

Retrofitting still faces many obstacles, especially in developing countries. Some of these barriers and/or obstacles include high initial costs [19], lack of end user's awareness [8], and the lack of financial institutions awareness. This is especially evident in the difficulty of allocating appropriate funds related to the implementation of energy-saving strategies and the costs that this entails [19]. In developing countries like Egypt, no firm policies exist that target the promotion of energy savings in buildings and their effect on climate change [20]. Another issue is the absence of reliable long-term forecasting plan or strategy for energy problems [8, 21]. The wide range of stakeholders involved, who could sometimes be ill-informed about the benefits of green retrofitting

[18] and the lack of information about life cycle costs also affect the decision-making process [18, 20].

3.3 Schemes and Approaches for Green Retrofitting

Many countries created supporting schemes to help in promoting green retrofitting in the existing building stocks. Examples of such schemes that were promoted in the UK include the Green Deal, the Energy Company Obligation (ECO), the Feed-in Tariff (FiT), and the Renewable Heat Incentive (RHI), [21]. Germany promoted the successful EuroPHit scheme, which was introduced by the Passive House Institute and was applied across Europe. The EnerPHit scheme funded by the EU provides a guide to the refurbishment of a sustainable building, generating a database of successful examples with many lessons learned [18]. An initial plan for green retrofitting has been developed in the UAE and it is envisaged to be completed by 2030 [22]. The aforementioned schemes are either financial motivational schemes, rating systems, or guidelines, with special emphasis on improving the energy performance of buildings. The above schemes adopted in different EU countries, feature different climates, which has a significant impact on promoting green retrofitting and would thus increase the performance of the different kinds of existing buildings. Figure 2 presents the main steps for carrying out retrofitting projects [23]. The above schemes and other retrofitting projects followed different approaches such as optimizing the building insulation, adding new windows, plugging air infiltration, air quality, and light saving by using LED, tuning up HVAC system, water saving appliances, landscaping and shading methods, etc.

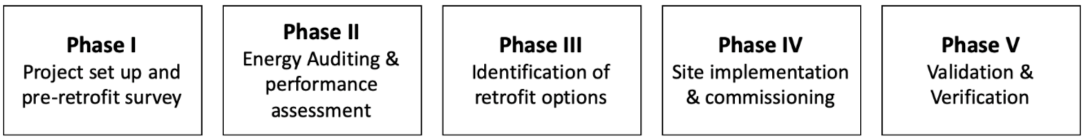

Fig. 2. Steps of green retrofitting [23].

Figure 3 summarizes the main reported technologies followed in green retrofitting. This paper will however address only two of them, the HVAC and the Energy Saving Appliances.

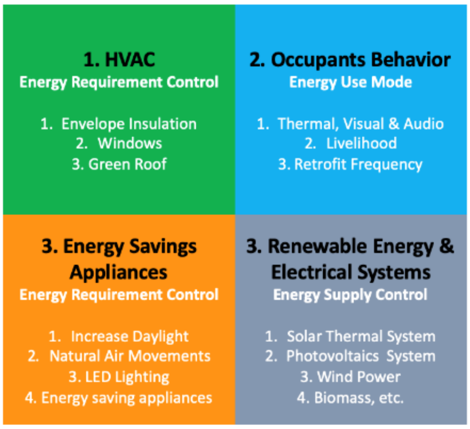

Fig. 3. Approaches of green retrofitting [5].

3.3.1 Whole building retrofit (deep energy/envelope)

An integrated design process can achieve higher levels of energy and cost savings by thorough analysis and considering the interactions between components. For example, improvements to the building envelope could dramatically reduce the cooling load in the building, and thus reduce the capital investment, energy, and maintenance costs associated with an expanded cooling system. Similarly, combining renewable energy installations with energy efficiency improvements may allow for the use of smaller and less costly renewable energy systems. The savings arising from the implementation of these energy efficiency measures could pay back the cost of the integrated renewable energy system introduced [18, 23].

3.3.2 Measure-by-measure (conventional energy/indoor intervention)

Due to the high initial investment cost of deep energy retrofitting, a step by step retrofit scheme has been developed to help guide a renovation process by breaking it down to different stages. The step by step retrofit approach helps set priorities for the retrofitting phases. In this way the building is renovated in stages by considering all the required modifications and making sure that the investments involved are fully optimized [18-25].

4. GREEN RETROFITTING EXAMPLES

Many green retrofitting examples of existing buildings were successfully carried out in different countries having different climatic conditions [6, 7, 15]. In Egypt, successful retrofitting also took place in educational buildings [5, 10]. This research focuses on the role of green retrofitting in enhancing the energy performance of a residential building. The selected case study is located in Paris, which has a Mediterranean climate, somehow similar to some parts of Egypt. The deep energy retrofitting approach will be applied to this building. The case study was selected as it is an internationally recognized building that was retrofitted rather than being demolished. Retrofitting resulted in cost benefits, energy savings, and the building became recognised for its enhanced performance. Needless to say that nowadays more advanced retrofitting technologies have evolved, making retrofitting more feasible and efficient. The second case study examined is a building in Oman which is characterized by a hot climate which is more similar to that of Egypt.

4.1. The First Case Study

4.1.1. Overview

The 16-storey Tour Bois-le-Prêtre was a deteriorated residential tower in Paris, which was designed by Raymond Lopez and was built in 1959-1961 [26, 27]. The building was once an example of modernism, and is 17 minutes from the Louvre. The building is 50 meters high and contains 96 apartments between maisonettes and split levels. Raymond Lopez the designer was influenced by Mies Van Der Rohe and his school. A state program was set forth where partial demolition of large housing projects constructed in the sixties and seventies of the last century was to take place. The Tour Bois le-Prêtre was a strong candidate as part of this urban renewal project. However, rather than its demolition, the option of retrofitting the building presented an opportunity to its modernization, while bringing back its value. The renovation included extending the plan outwards to give more space and to create balconies as seen in Fig. 4.

Fig. 4. Extending the plan outwards, Tour Bois le-Prêtre [26].

4.1.2. Details of the project

The idea was to introduce a winter garden that extended the plan outwards and acted as a balcony for the apartments. This idea also allowed minimum intervention so that the occupants could still use the building while the renovation took place. Figure 3 presents the architect's strategy for the retrofitting plan. The existing façade was to be replaced by an extension module measuring 3.5 × 7.5 m. The modules were added one at a time from the bottom to the top of the building. The steel structure supporting the new modules was separated from the building in order to allow the operation to take place with minimum intervention. The boundary between the balcony and the winter garden was fitted with corrugated polycarbonate sheets or a single glazing panel. The façade, on the other hand, between the interior and the winter garden was double glazed. The retrofitted floor to ceiling windows allowed no obstruction of the view from the apartments and allowed daylight to penetrate within. Glazed sliding doors partitioned the old façade from the newly added extension. Internal thermal curtains consisting of aluminium foil, wool, and fabric were also to act as movable sun breakers. They also help control the indoor climate by allowing the sun to enter and heat the place in winter while blocking it in the summer for a cool and comfortable interior. Figure 5 presents the passive summer and winter thermal performance of the curtains. This simple method helped reduce the heating cost by about 50% for the occupants while improving the building's efficiency.

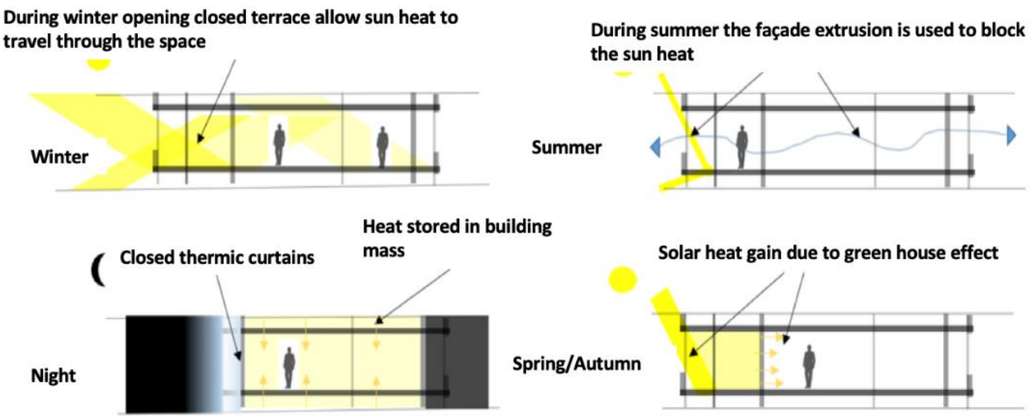

Fig. 5. Passive summer and winter thermal performance [27].

The total net cost of the retrofitting operation was around Euros 11.25 Million, which comes to around Euros 112,500 per apartment [27]. Though the retrofitting cost was high it was about half the cost that the demolition and reconstruction would have entailed [27].

4.2. The Second Case Study

The second case study is located in the Sultanate of Oman to represent a region with a hot climate that resembles the hot summer Egyptian weather. A typical one floor residential building was analysed in terms of insulation, cooling, lighting and shading using Design Builder software and the Energy plus graphical user interface [28]. The building was analysed using hourly analysis data for 2014, and the results indicated that the impact of the coefficient of performance (COP) of air conditioning, roof insulation, LED, reducing air infiltration, and wall insulations had a significant impact on the annual energy consumption. The energy savings arising from each of the above interventions were respectively 25.9%, 12.1%, 7.23%, 5.24%, and 3.9% [29]. This illustrates another successful case in terms of a residential retrofitting using a mix of both envelope and indoors measures.

5. GREEN RETROFITTING IN EGYPT

In Egypt, green retrofitting is a promising solution to save energy and attempting to approach a more holistic utilization of energy. However, it is essential to point out that sustainability should be addressed initially during the design phases of any building, which will give more cost-effective results rather than when introduced to an operating building. Yet, in the Egyptian building market the environmental awareness is still struggling and the lack of resources and dedicated capital hinder the direction towards green retrofitting [5]. Choosing sustainable means whether green retrofitting or any other mean all depend on users' awareness to be able to achieve clear economic savings [8]. On the other hand, the promotion of green retrofitting in the Egyptian market so far has focused more on commercial and education buildings [6, 7, 9, 10]. An example of educational building retrofitting in Egypt was reported by assessing the energy performance of one of the buildings at the Arab Academy of Science, Technology and Maritime Transport campus in Cairo. The study revealed that average savings up to 27% of the energy used in the building could be reached when using glazing and the envelope insulation of the building [10]. Focusing on residential buildings and to highlight the possible energy savings, the following section will investigate a local case study, utilizing both the HVAC system and other energy saving technologies. This will be followed by highlighting the means and actions required for promoting green retrofitting, and identifying the main roles and responsibilities of the different stakeholders with regards to the Egyptian market.

5.1. Local Case Study

In Egypt and particularly in Cairo, around 2,587,852 households consume 7,745.25 GWh of electricity annually [8]. A local Cairo based residential unit will be analysed, after introducing some minor retrofitting interventions to indicate possible venues for energy savings. The case study will focus on how to decrease energy consumption of the selected unit’s lighting. Figure 6 shows that cooling requirements also constitute considerable sources for energy consumption in residential buildings and hence will have a more significant impact in terms of energy savings and in enhancing the energy efficiency.

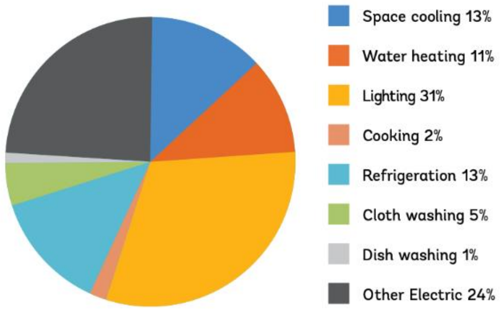

Fig. 6. Residential energy use in Egypt [8].

5.1.1. Software description

The commercially available Hourly Analysis Program (HAP) will be used for energy analysis. This program was developed by Carrier and has been widely used and is internationally acknowledged. HAP can be used to compare energy consumption and operating costs of different design proposals or scenarios [30]. The latter option will be used in this case study to analyse different scenarios and compare the results to illustrate possible energy saving potentials. Retrofit actions range from the simplest form of intervention, such as replacing a bulb with a LED one, to more sophisticated ones such as replacing the exterior wall insulation, or improving the cooling system [26]. The proposed scenarios for the case study will follow the conventional retrofit approach namely measure by measure rather than the deep energy retrofit approach to demonstrate that the savings arising from even minor interventions could be significant.

5.1.2. The selected unit

The selected unit is located in a compound called Acacia, Fifth Settlement, in front of Al-Rehab City gate no. 6, New Cairo, Egypt. The compound is divided into different units, and the selected unit is among the apartment units. The right unit facades orientation faces the Northwest, Northeast, and Southeast, while the left unit facades orientation faces the Northwest and the Southwest. One of the main reasons for selecting this specific unit was to guarantee that all facades are well ventilated and lit. This is to remove the effect of these two factors from the calculations. The calculations carried out on the selected apartment unit will attempt to highlight possible means to increase the efficiency of the cooling units and the artificial lighting type in order to be able to determine the possibility of reducing the energy consumed within the unit. Figure 7 shows the location of the AC units required for cooling in each space of the selected unit. The areas considered are the reception area, and three different bedrooms. The hottest month of the year, which is usually August was selected in the calculations. HAP has been used to study the cooling load for the different scenarios to indicate possible outcomes. The results will be compared and analysed, highlighting the possible savings that would arise following this measure by measure approach.

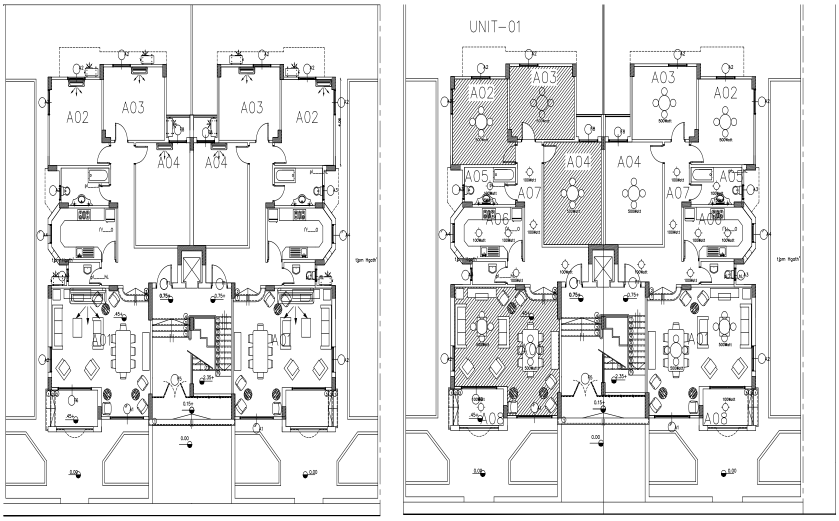

Fig. 7. Selected spaces of study and AC placement in the selected unit.

5.1.3. Analysis

5.1.3.1. First scenario (Conventional inputs)

The general information obtained from the actual case was entered into HAP. The givens include the use of typical brick walls and the use of conventional incandescent light bulbs in lighting the space. The calculated total cooling load required is around 25.7 kW, and its distribution within the space is shown in Table 1.

Table 1. Cooling load for the conventional case.

Space	Load, Horse power	Load, kW	Load, BTU	% from total
Reception	5	11.72	40000	45%
Bedroom 1	2.25	5.27	18000	20%
Bedroom 2	2.25	5.27	18000	20%
Bedroom 3	1.5	3.52	12000	15%

5.1.3.2. Second scenario (LEDs)

In this scenario, LED lighting rather than conventional incandescent light bulbs were used and the data was entered into HAP. The walls were retained as plain brick walls like in the first scenario. The calculated total cooling load required is around 24.03 kW, and its distribution within the space is shown in Table 2. It is noticed that though there is no big difference in larger spaces like the reception, however there is a noticeable difference in smaller bedroom spaces.

Table 2. Cooling load using LED lighting.

Space	Load, Horse power	Load, kW	Load, BTU	% from total
Reception	5	11.72	40000	49%
Bedroom 1	2.25	5.27	18000	21%
Bedroom 2	1.5	3.52	12000	15%
Bedroom 3	1.5	3.52	12000	15%

5.1.3.3. Third scenario (Wall Insulation)

In this scenario, conventional lighting sources were retained but wall insulation was added in the data entered into HAP. The insulation assumed is 6 mm thermal foam boards, which is available in the local Egyptian market and is popularly used. Its cost is around EGP 750 per m^2. The calculated total cooling load required is around 21.01 kW, and its distribution within the space is shown in Table 3. It is noticed that savings are considerably more pronounced when using wall insulation.

Table 3. Cooling load adding wall insulation.

Space	Load, Horse power	Load, kW	Load, BTU	% from total
Reception	4.5	10.55	36000	49%
Bedroom 1	1.5	3.52	12000	17%
Bedroom 2	1.5	3.52	12000	17%
Bedroom 3	1.5	3.52	12000	17%

5.1.3.4. Fourth scenario (Hybrid Case)

In this scenario the input to HAP are adding insulations to the wall (similar to the third scenario), using double glazed windows, adding overhangs to the windows for shading and using LED lighting sources. The total calculated cooling load required is around 17.58 kW, and its distribution within the space is shown in Table 4.

Table 4. Cooling load for the hybrid case.

Space	Load, Horse power	Load, kW	Load, BTU	% from total
Reception	4	9.37	32000	54%
Bedroom 1	1.5	3.52	12000	20%
Bedroom 2	1	2.35	8000	13%
Bedroom 3	1.	2.35	8000	13%

In this hybrid case, a higher level of intervention is needed. This is associated however, with considerable savings. It is noticed that the measures taken were easy to install and can be carried out during the usual occupation of the building. The initial investment in this fourth scenario is the highest however, it is still within an acceptable limit and will be paid back by the savings arising from its implementation.

5.1.4. Results and findings

Figure 8 presents the different energy saving levels arising from the application of the different scenarios.

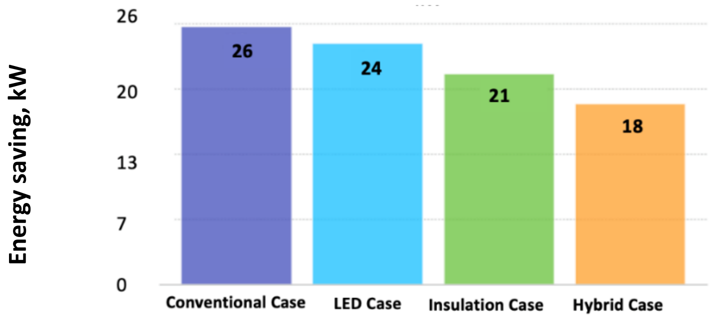

Fig. 8. Savings analysis in kW.

It may be concluded from the above analysis and referring to the international examples, that the conventional and deep energy retrofit approaches can contribute to considerable savings in terms of energy use in residential buildings. The main findings of the case studies are summarised as following:

- In the Tour Bois-le-Prêtre, Paris case it is to be noted that although the initial cost of the retrofitting was high, retrofitting was more cost effective than demolition and reconstructing a new residential building. Also, the energy savings associated with the retrofit could pay back the initial investment in a few years.

- In the Oman case study, it is important to highlight the role of air conditioning in decreasing energy use, and inducing the highest energy savings, especially when considering the hot climate of Oman.
- Analysis of the different scenarios generated for the New Settlement, Egypt building showed that the hybrid case, combining different measures, was the best solution in terms of saving on the total cooling load. Also, in this case, the initial investment was higher than the other scenarios but will also be paid back from the savings arising from energy conservation. This is addition to providing an overall more comfortable environment for the users.

It is to be noted that the deep retrofitting approach will most certainly give better results with respect to energy savings. However, a higher initial investment is expected and the implementation period could be longer as with the Tour Bois-le-Prêtre, Paris case.

5.2. Promoting Green Retrofitting in Egypt

It is seen from the above results and analysis that green retrofitting presents an effective solution for increasing energy efficiency n Egypt. However, for its promotion to be properly introduced to the market a guideline should be composed. This guideline would help to increase the awareness towards green retrofitting benefits while also address the roles and responsibilities of different involved stakeholders.

5.2.1. The role of developed countries

Developed countries such as the EU, UK, USA, Canada, and Australia [8] have realized the critical role of green retrofitting, and they developed means, tools, and different incentives through laws, regulations and schemes in order to promote its use. Developed countries, as pioneers in this field, could help developing countries through investment schemes, awareness campaigns, illustrating lesson learned and best practice examples, in addition to exporting different possible technologies for retrofitting.

5.2.2. The role of the Egyptian government

The government has a vital role to play in the promotion of green retrofitting starting by increasing the public and user's awareness. Some activities that could be carried out by the government are summarized below.

Role modelling: The government could start by investing in and sponsoring public projects that adopt the applications of green retrofitting schemes. This could be done by retrofitting a few public buildings such as schools. This would help influence the perception of youth towards green retrofitting and the necessity of sustainability. Partnerships with the private sector to create funding schemes such as green mortgages and loans systems would also help. Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, and Slovakia [8] are among the countries who successfully promoted such partnerships.

Awareness Campaigns: The government could advocate public campaigns to help in promoting sustainability in general and green retrofitting application to obtain energy-efficient buildings in particular. The main aspects that could help in promoting green retrofitting are that it can help reduce the electricity bills and hence the energy demand of buildings. It will also enhance the building status and can help improve occupant health in many cases. Another important aspect is that it can save on maintenance costs and open the door to a new green market niche, hence creating new jobs opportunities. This would also help in achieving sustainable development goals in the long run.

Incentive laws and regulations: Generating incentive laws and regulation to encourage developers and investors to use green retrofitting schemes. This could be done through tax reduction or facilitating procedures presented to developers that choose to renovate or retrofit existing buildings. Furthermore, using obligatory regulations is also essential. Example countries: Belgium, Canada, Denmark, France, Ireland, Italy, Netherlands, UK, USA, [8].

5.2.3. Other roles and responsibilities

Another critical factor in promoting green retrofitting and sustainability is by engaging all the parties involved and increasing their awareness about the process and its benefits. Enhancing end-user's awareness and alerting them to the features and benefits that green retrofitting can provide, will encourage them to seek similar methods and hence will expand its demand. It is crucial to engage with the public and allow them to participate in the decision-making process from the start of any scheme that will serve them and their interests in the first place. This in return will give them the power of choice and will allow them to accommodate their actual needs and combine their real desires in the process. By encouraging users to relate to their environments and understand its needs, schemes such as green retrofitting will become a naturally obtainable decision.

Finding well skilled labor is a challenge facing green retrofitting. Accordingly, there should be means to facilitate skills development. The government and other stakeholders should provide workshops and professional training, and any other means to promote the use of green retrofitting and enhance its know-how. A constant educational process is required to promote and maintain this field.

Architects and designers also play a crucial role as they are actively aware of the different applications that can help increase building efficiency and promote energy savings. However, these applications are not often used as the clients and building owners are not aware of them. In some cases, the architect will invest considerable effort in designing buildings that are environmentally friendly or energy-efficient yet when it comes to tenants taking over the building, all the architects' efforts could be ignored. Therefore, it is important to encourage and revive sustainable consciousness in designers along with the awareness of the users, in order to promote the use of different sustainable solutions such as green retrofitting.

6. CONCLUSIONS AND RECOMMENDATIONS

Analysis of some international and local case studies revealed that there are potentially considerable impacts in terms of energy savings in the residential sector through robust, accurate, and cost-effective retrofit activities for existing buildings. This is particularly applicable in a country like Egypt, where the residential sector constitutes the highest consumer of energy. In this research, references were made for both deep energy retrofitting and conventional energy approach in international case studies. However, the local case study focused more on the conventional energy approach. Hence, the research limitation highlights the possible future work in terms of deep energy interventions, on a local case study, which can illustrate even more profound results in term of energy saving.

Although many studies illustrated the possible energy savings potentials arising from green retrofitting of residential buildings, its promotion is still limited and needs a clear formulated guideline. The required actions are to be initiated by the government while involving all stakeholders. The following points highlight the main steps and incentives that the government could adopt to promote green retrofitting.

- Incentive laws and regulations such as tax reduction, funding schemes, and obligatory laws should be enforced to assure the application of green retrofitting in all possible cases.
- There should be proper data collection to facilitate the participation of end-users. Another point is providing regional and contextual appropriate rating building tools like those developed in many countries, which can be used as a guideline to increase the energy efficiency of buildings and make them more sustainable. Green mortgages or credit guarantees mechanisms successfully used in many countries could be adopted. Another method would be utilising energy efficiency standards such as LEED, BREEAM, etc. These tools would help in promoting and marketing the building, which makes it a better asset for its owners and occupants.
- Workshops, promotions and marketing campaigns would help as an investment in the new generation sustainability education.
- Suggesting better mortgage and renting schemes, increasing property value, saving on bills, and saving on maintenance cost are also plausible incentives.
- Other incentives include better occupant's health, corporate responsibilities, and creating a new green market niche and green job opportunities.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interests.

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تعزيز عمليات إعادة التأهيل الخضراء لتحسين توفير الطاقة للمباني السكنية في مصر

تلعب المباني دورًا أساسيًا في أي اقتصاد وطني، إلا أنها تساهم بشكل كبير في استهلاك الطاقة العالمي. يظل مخزون المبنى القائم جزءًا صعبًا وحاسمًا من المعادلة. يمثل تحقيق الاستدامة في مخزون المباني القائم تحديًا بشكل خاص في بلد مثل مصر، التي واجهت أزمة طاقة حادة قبل بضع سنوات، وحيث يكون القطاع السكني تحديدًا مسؤولاً عن حوالي ٥١٪ من استهلاك الطاقة في البلاد. تهدف هذه الورقة إلى تسليط الضوء على دور التعد اعادة التأهيل الأخضر في تعزيز أداء الطاقة في القطاع السكني المصري. تعتمد الورقة منهجية شاملة لمراجعة الأدبيات لإدخال اعادة التأهيل الأخضر، وتسليط الضوء على فوائدها. سيتم استخدام دراسة حالة دولية كجزء من الأدبيات لتسليط الضوء على التوفير المحتمل للطاقة من خلال اعادة التأهيل الأخضر، وسيتم تحليل دراسة حالة محلية أخرى بدقة باستخدام برنامج "HAP" كدليل إضافي على توفير الطاقة المحتمل. تختتم الورقة بإلقاء الضوء على الإجراءات المطلوبة لتعزيز التعد اعادة التأهيل الأخضر في السوق المصري مع تناول أدوار ومسؤوليات مختلف أصحاب المصلحة، بناءً على نهج أكثر شمولية لتحقيق الاستدامة في قطاع البناء على المدى الطويل.