BUILDING REFURBISHMENT STRATIGIES AND THEIR IMPACT ON SAVING ENERGY IN THE UNITED ARAB EMIRATES

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ABSTRACT

In the United Arab Emirates (UAE), buildings in different sectors (governmental, commercial and residential) consume around 80% of electrical energy. The newer buildings are constructed with strict green regulations in order to mitigate the impact of the built environment. However, existing buildings are still responsible for a big portion of electrical energy consumption. By law, all the federal buildings in the UAE are required to implement energy saving measures. Despite this, the existing residential and tertiary sectors are moving at a slower pace towards increasing their energy efficiency. This paper provides an analytical review of a range of drivers and technical measures that have been implemented in energy efficiency cases in the UAE to highlight their impact on reducing energy consumption. Also, interviews are held with some ESCOs in the UAE to underline their best course of actions to achieve energy efficiency during building refurbishment. The study reveals that efficient building envelope, HVAC optimization, efficient lighting and use of free resources of water heating are the most common measures for buildings' refurbishment in the UAE. Aggressive retrofitting could provide up to 50% saving of energy consumption. However, many issues still need to be considered in implementing these measures such as economic feasibility and financing options.

Keywords : *building refurbishment, United Arab Emirates, energy saving measures, energy efficiency, existing buildings, energy consumption.*

1 INTRODUCTION

Buildings are the major factor of energy consumption with 40% CO_2 emission. [1]. In 2008, the residential and tertiary sectors were accounted as the highest final energy consumption by 33% worldwide, with 53% of this energy used as electricity consumption.[2]. The last three decades in the UAE have witnessed an active building in the construction sector. Unfortunately, in 2010, the country was reported as the highest ecological footprint worldwide in the year 2007[3]. As a result, the UAE government has decided to partner with Copenhagen Accord[4] and has shown commitment to reduce CO_2. A research about the UAE explained that tackling the built environment with serious regulations regarding energy consumption issues, as well as replacing fossil fuels with clean energy sources, will reduce the emission of CO_2 by 50% [5]. Therefore, the built environment sector has shown provision of standards and codes that regulate the new constructed buildings such as Estidama with its 1 Pearl and 2 Pearls rating in Abu Dhabi in 2010, and Dubai Green regulation in 2011.[6,7] However, the majority of these efforts have focused on new buildings, whilst the existing buildings were neglected. The new construction will only make up 0.5-2% of the total building stock and will contribute 10%-20% additional energy consumption by 2050 [8,9]. Therefore, the existing buildings prior to implementing energy efficiency's codes and regulations have remained as a major source of CO_2 emission. It is evident that considering retrofit of the existing buildings is the most practical and fastest way to reduce the CO_2 emission; as shown through Etihad super ESCO's accomplished work on refurbishing some federal buildings. However, to achieve an aggressive reduction in GHG emissions, the commercial and the residential sectors need to be included as well[10]. It has found that these two sectors in Dubai and Abu Dhabi are responsible for 40% & 43% of the energy

consumption in the UAE [11]. Moreover, in the emirate of Abu Dhabi, around 80% of electricity consumption is attributed to buildings. Fig. 1.

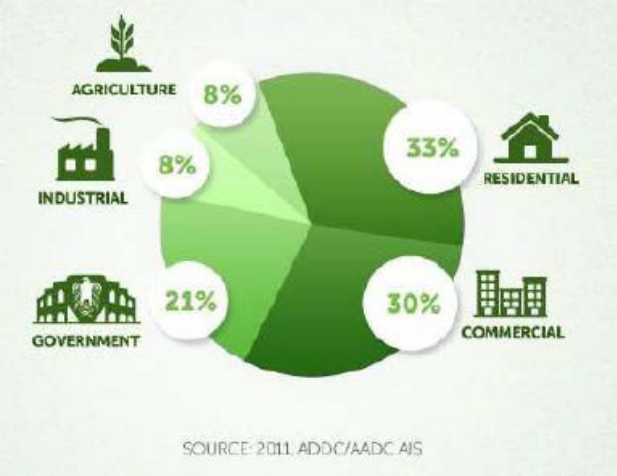

Figure 1: Electricity Consumption in Abu Dhabi Emirate

This paper provides an overview of a range of drivers off and technical measures that are implemented in energy efficiency cases in the UAE to highlight their impacts in reducing electrical energy consumption. It will also aim to highlighting the great potential of these measures to help encourage stakeholders to hasten the pace regarding all the sectors in the retrofit market. Moreover, interviewing major ESCOs members in the UAE to highlight the opportunities and challenges that face the retrofit local market.

2 BUILDING REFURBISHMENT

Energy efficiency is the management of energy usage to provide the intended task with less energy consumption and without compromising the individuals' thermal comfort. There are different measures and techniques and could be applied to new or existing buildings. The main factors that need to be considered at all times are: the reduction in energy consumption, the reduction in CO_2 emission, the cost effectiveness, and the indoor air quality. Refurbishing existing building stock is a very challenging task because of the high level of uncertainties, as well as the vast diversity of the existing buildings with their different typologies (age, location, function, orientation, materials, occupation, policies, etc.). Moreover, the interaction between the different subsystems increase the complexity of this task and the difficulty to choose the appropriate measures. In addition, the funding aspects in terms of initial capitals and potentially long payback periods also add to these challenges [12-14]. Due to these barriers and challenges, the progress in the retrofit industry in some countries including the UAE, is limited. Many studies have discussed the environmental, economic and social benefits of retrofitting existing. [15,16]. Energy computer modeling methods have been applied in many papers to evaluate the effectiveness of a wide range of retrofit measures. For instance, in 2011, in Greece, the Hellenic building stock was chosen as a case study to figure out the in energy savings potentials relating the different typologies. Also the study focused on finding the most efficient energy conservation measurements with the prioritization of the maximum outcomes. The simulation results showed that the older the buildings, the bigger the chance of saving energy. Even applying standard measures that deal with the building envelope's thermal insulation can offer great energy saving potentials [17]. However, it was found that the energy consumption reduction, due to implementing different measures, is not the sum of their individual impact. The interactive effects between these measures play an important role in increasing their efficiency. A simulation of all combined energy saving measures must be included in order to obtain the complete picture of the energy consumption [18]. Regarding GCC countries, for example a hotel building in Qatar, was chosen as case study to assess some energy conservation measures such as; building envelope, changes in customers' behaviors and implementing renewable energy supply [19]. In the UAE, papers presented different scenarios of upgrading the energy efficiency of selected existing case studies in Abu Dhabi that had been built during different decades [20,21]. The energy consumption for the upgraded scenarios were evaluated and compared to the energy consumption of the as-built case. One paper went beyond just presenting the energy saving and evaluated the economic impact of implementing such energy saving measures [21].

2.1 Retrofit Measures

A retrofit is upgrading the buildings' operational and physical systems to become more energy efficient [22]. Retrofit measures can be applied to the building's envelope (passive measures), or to its electrical and mechanical systems (active measures), or could be related to some changes in the occupant life style (behavioral measures) [23]. Many factors play a role in choosing one measure over another, such as feasibility, applicability and outcome for each measure. For example, upgrading HVAC system can offer great saving in energy consumption especially in commercial buildings; yet, it is considered a costly option. On the other hand, enhancing the building envelope through passive measures could be more feasible despite the lower energy saving that they could result from it [24].

Passive Retrofit

Passive design strategies are considered among the most effective ways to save energy consumption [25]. Shading devices as a passive strategy have been investigated in many researches to highlight their impact in mitigating the solar gain; hence, reducing the energy consumption for cooling purposes [26-28]. Many factors affect the shading impact such as the building layout, the windows' orientation, the site location and limitation [29]. In 2013, a study was conducted to investigate the impact of external shading and windows' glazing on thermal performance of a residential building in Abu-Dhabi, UAE. The study revealed that 10% reduction in cooling bills is possible through applying simple passive design strategies [30].

Thermal performance for the walls and roof is another important passive measure. Many research papers discussed the impact of insulation materials in reducing energy consumption and how different factors could affect the outcome result. For example, the type and the thickness of the insulation materials, their locations, the climatic zones that they have been used in, all play an important role on the insulation efficiency. [25,31,32] In the UAE, two papers discussed the potential in energy reduction through enhancing the thermal performance of the building envelope [20,21]. It was found that applying 1 pearl and 2 pearls can provide up to 31% reduction in annual energy consumption. Moreover, another paper showed the simulated result of a residential villa in the UAE. By considering the thermal bridging in buildings, it was found that besides using the insulated blocks, a full perimeter of 50 mm of EPS insulation could provide around 24.5% reduction in energy consumption. This result could reach up to 30% with 160 mm EPS insulation [33]. Regarding glazing, also many researchers investigated the effect of glazing type and orientation on energy consumption level. It is clear that double glazing provides a great impact in mitigating solar gain and is important as the opaque material insulation [34]. Other studies in the UAE simulated the reduction of energy as a result of replacing single glazing with double glazing, the reduction in energy consumption reached up to 15% [35,36].

Active Retrofit Measures

In this section, retrofit measures deal with the systems that provide lighting, domestic hot water, heating, cooling and ventilation (HVAC). Improvements could include the replacement of boilers or chillers, providing efficient lighting fixtures and the instalment of solar domestic hot water (SDHW). Research shows that operating the chillers system of the HVAC consumes half of the energy demanded. Over the years, the coefficient of performance (COP) increased dramatically. A 0.36% saving in electricity could be achieved by increasing the COP of chillers from 5.73-5.85 [37].

DHWs are responsible for large consumption of energy reaching around 18% in the UK in 2009 [38]. However, in the UAE, in the same year, only 3% of electricity is used for heating water in commercial sectors in Abu Dhabi [39]. SDHWs are considered one of the lowest cost technologies, yet it is very important and effective in energy efficiency [40].

The lighting system is a vast area needing improvements regarding energy efficiency. Many studies investigated and compared several retrofit options. It was found that energy savings could be easily achieved by enhancing the electric lighting system. such as considering T5 fluorescent lamps, CFLs or even LED lamps, as well as applying manual or automatic dimming and occupancy sensors

[41]. In the UAE, a recent study examined the impact of lighting system retrofit by reducing energy consumption in federal buildings. LED lights proved to be the best energy savers in spite of the high cost for each unit. Occupancy sensors resulted in 10% energy reduction, while, daylight sensor and dimming systems resulted in 25% energy reduction [42].

Combined Passive and Active Strategies

Mixed applications of passive and active retrofit measures could lead to a significant reduction in energy consumption. A recent research paper in Lebanon focused on evaluating energy conservation measures ECMs with low investment values and without any changes on the building envelope. It was found that a 7.2% reduction in annual electrical energy can be achieved by implementing the air economizer, 3.4% by increasing the cooling set point temperature, 2.6% by providing occupancy sensors and scheduling of lighting, and 0.9% as a result of night purging. Moreover, using condenser air which is cooled by condensate drain adds an additional annual saving of 2.1%. [43]. On the contrary, a study in the UAE was conducted on an existing building in Abu Dhabi to evaluate passive and active measures such as: wall and roof insulation, glazing replacement, chillers' COP, enhancing the building's air-tightness and increasing the cooling set point temperature. The result revealed how low cost or zero cost measures, such as changing the cooling set point temperature, are very effective strategies [44].

3. STATUS OF REFURBISHED EXISTING BUILDINGS IN THE UAE

Demand side management (DSM) is part of Dubai's integrated energy strategy 2030, which promotes energy conservation by affecting consumption behaviours in different areas. Among their targets is to achieve electricity consumption savings as well for water consumption savings each by 30%. The Building Retrofit Program is among DSM's eight programs with an ambitious goal to retrofit about 30000 buildings by 2030 [45]. The program is targeting the main consumption drivers. As a kick start for this program, Etihad ESCO was launched and followed with provision of contractual framework and Energy Service Companies (ESCOs) accreditation by the Regulatory and Supervisory Bureau (RSB). ESCOs are commercial businesses that provide a wide range of energy solutions such as: designing and implementing energy saving projects, energy conservation, retrofitting and risk management [10]. Moreover, a Directive for Energy Audits and Retrofit in government organizations was issued by the Supreme Council of Energy and followed by detailed implementation guidelines. The Directive for Energy Audit states overall targets and assigns responsibilities for leading the effort. However, the implementation guidelines is a 10 page booklet defining the technical requirements, roadmaps, timing and type of support offered to government organization [46, 47]. The challenges and obstacles that hinder the progress in nongovernmental buildings will be discussed in the final section of this paper.

3.1 Retrofitted Projects in UAE

DEWA Buildings, Dubai

Dubai Electricity and Water Authority (DEWA) is an organization owned by the government. The Etihad ESCO was tasked with retrofitting all DEWA buildings. 55 energy conservation measures were installed including the replacement of the old air-cooled chiller plant in DEWA's main office, the replacement of other chillers, pride motors and pumps with Variable Frequency Drives (VFDs), and the instalment of evaporative cooler on chillers, variable fresh air flow system with CO2 sensors, solar films on windows, timers and controllers, occupancy sensors for lighting system, water efficient fixtures, energy management centre, etc. According to the project's data, there was a 31% reduction in energy consumption equivalent to 5GWh per year, saving 2.6 Million AED annually. The investment of 16 Million AED by DEWA will be paid back through the savings within 6 years. Eventually, 2,245 tons of CO2 emission was avoided [48].

Festival City , Dubai

Selected buildings have been chosen for energy management plan EMP and retrofit measures were implemented including optimizing the cooling set point temperature for the AHUs and the FCUs of public areas, activating the control system and pressure feedback ΔP of the

variable speed drivers of the chilled water pumps to allow the system to work efficiently and on demand. Moreover, optimization of the frequency of the chilled water pumps VFD were done in order to control the quantities of chilled water during non peak periods. In the mall, the extract fans in the toilets have been switched off during the non working hours. Also, the internal lighting and water features during operational hours in the mall and atrium have been reduced as well. As a result, in 2012 DFC achieved the highest energy efficiency compared to all the previous years with an annual cost savings of AED 3,565,729. DEWA bill savings of the District Cooling Plant (DCP) was 8.58% less than 2011. For the shopping mall, the saving in electricity consumption in 2012 comparing to 2011 was 818,942 AED which is equivalent to 6.3% [49].

3.2 LEED-EBOM Certification

To obtain this certificate, the building needs to be occupied no less than 12 months with an occupancy rate of 75% or greater. In the UAE, some buildings are considered iconic by obtaining LEED and LEED EBOM certificates.

Dubai Chamber of Commerce and Industry

It is considered the first building in the Arab world that achieved the ENERGY STAR label with the "most efficient" rating of 91, meaning it consumes less energy than 91% of similar buildings in the US. Also, it is the first building in the region to achieve LEED EBOM in 2009 and eventually reached the platinum level in 2013. Its LEED Platinum was a result of 15 years of effort. Between 1998 and 2008, water and energy consumption was reduced by 77% and 47% respectively with $1.93 million saving through low and no cost initiatives. [50] The energy saving initiatives were: enhancing chiller performance, maintaining adequate room temperature, enhancing lifts efficiency, improving lighting system and replacing the conventional heat exchanger. By reducing the chiller water circulation requirements, there was an energy saving of 10,000 KWh/year. This iconic building was able to save about 22,701 tonnes of CO^2 emission between 1998 and 2008 [51].

4 THE TRUTH AND CHALLENGES IN RETROFFING BUILDINGS IN THE UAE

The government has shown a very positive attitude towards energy efficiency programs, which has helped in provision of many initiatives and regulations. Based on the latest statistics, there are 120,000 buildings in Dubai, amongst which 30,000 buildings were identified with high energy saving potential. Etihad ESCO currently focuses on the few thousand buildings related to 28 governmental authorities, the remaining buildings are unexploited [52]. A survey in 2012 was conducted in order to collect information regarding the existing buildings' construction before the insulation regulations were implemented in 2003. The task was more difficult than anticipated due to the different practices used every decade (1970s, 1980s, and 1990s) [53]. It is evident that the vast diversity of the existing stock in the UAE with the lack of accurate construction information and the absence of codes that regulate the refurbishment market shape the retrofit process as a challenging task.

4.1 The Barriers

Many consumers or investors tend to lack interest in these retrofit projects either because of the decreased awareness regarding the prospect of energy savings, or lack of confidence in energy efficiency suppliers. Regarding the technical barriers, the market still shows limited size and resources to take up worthy projects, in addition to shortages of expertise to cover a project's full scope; however, the financial aspects of funding such projects is considered by far the biggest barrier. Although many actions and incentives have been provided to overcome some of these barriers, the finance aspect still needs a lot of effort in order to ease the retrofit progress in all building sectors [1,10,54].

The UAE is a large market with limited accredited ESCOs. As a governmental initiative, RSB launched its accreditation program to tackle the shortage of qualified ESCOs. The Energy Management Service company (EMS), is one of the biggest accredited ESCOs in the UAE. The CEO, Khaled Bushnaq, explained the importance of ESCOs as a main player in the retrofit market which provides a broad range of energy efficiency solutions. He added that the newer

breed of ESCOs was interested in providing innovative funding methods. Harris Sanoo, a senior manager in EMS, explains that a preliminary audit is the first step to giving an initial estimation, followed by a detailed one which will highlight the most energy demanding loads. He added that in a typical utility, the HVAC consumes the most energy, about 40% of the total energy, while lighting system consume around 15%. Many factors affect decision making regarding the chosen measures, such as the initial cost and the payback period. EMS estimates the energy savings percentage for some measures as following: LED lighting: 50-80%, occupancy sensors: 25-80%, lighting reflectors: 25-50%, daylight pipes: 50%, lighting control system: 25-50%, heat reflective paint: 7-10%, heat recovery wheel: 40%, refrigerant additive for chillers: 10%, and AC smart controller: 10%. On the other hand, water saving measures will contribute as following: waste water recycle: 70%, water saving devices: 40%, waterless urinals: 100%, dual flush toilets: 30%, and infrared sensor based faucet: 30%. Mr. Sanoo explained that the first retrofit measures should enhance the envelope insulation (cool paint, films for glazing), which could provide a 10% saving; however, the payback period is long. Almanarah Tower in Sharjah was among the retrofitted project with EMS. No mechanical measures were provided and the retrofit focused on the mechanical aspects such as: chiller sequencing, heat recovery wheel, HRWs ventilation and CCC including Energy Meters. The final saving measures reached 23.74%. Moreover, Alkhaleej Center in Dubai implemented some electrical and mechanical measures. The electrical strategies provided 6.10% saving, while retrofitting some mechanical parts contributed with 17.28% saving to have a total of 23.38% savings in energy consumption [55].

5. CONCLUSION

Retrofitting existing buildings has great potential in saving energy consumption and mitigating the impact of the built environment on climate change. Although the UAE is considered among the leaders in this field in the Arab world, a lot of energy saving potential are unexploited due to some barriers in funding. According to the climatic conditions of the UAE, most of the used measures dealt with enhancing the insulation of the building envelope, upgrading the cooling chillers in the HVAC system, enhancing the lighting system and implementing solar domestic water heating. Feasibility and finance play an important role in choosing these measures.

Successful retrofitted cases in the UAE have proven that energy efficiency is a powerful, effective and fast way to save energy and money.

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