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A METHODOLOGY FOR SUCCESSFUL RETROFITTING IN THE UAE OLD RESIDENTIAL SECTOR TOWARDS SUSTAINABLE MEASURES

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INTRODUCTION

Global warming is one of the greatest protuberant defies our planet is currently facing. Recent reports by Intergovernmental Panel on Climate Change (IPCC) confirms both the seriousness of the climate change challenges and the deep carbon emission reductions that are needed to avoid the worst to the global ecosystem with a direct impact on the wellbeing of human life (Global Issues, 2014). It is believed that the built environment contributes to global warming through two main practices. First, buildings are responsible for relatively more than 40% of the materials consumption, and second, over one third of the total greenhouse gas emissions and other harmful atmospheric emissions in the world is caused by the building industry (UNEP, 2009). Recent studies by the United States Green Building Council revealed that the commercial and residential building sector accounts for 38% of carbon dioxide (CO2) emissions per year, more than any other sector in the country (USGBC, 2010). Accordingly, the past few years witnessed the call for of environmentally conscious design.

Presented as a case study in this research, the United Arab Emirates[i] (UAE) witnessed rapid economic expenditure and high population growth rates in the past few decades. Such trends were accompanied with a fairly low-energy cost to inspire development, yet resulting in significant increase in energy consumption, making the UAE one of the highest energy consumers per capita in the world (Kazim, 2007).

UAE's environment is characterized by high concentrations of airborne dust particles and high humidity, which tend to diffuse and attenuate the intensity of solar irradiance. In recent studies, the country was ranked 10th among the top 21 countries with higher consumption per capita in the world (10133 Kwh) and 2nd among top 30 in CO2 emissions per capita (27.14 kt) after Singapore. Growing large scale construction activities, in addition to formerly absence of sustainable standards in the old residential sector have considerably contributed to these capacities. To elaborate on such capacities, according to studies by the World Resources Institute - Climate and atmosphere UAE (2006), the building construction and operation practices are responsible for 4% of the CO2 production through direct emissions, 43% by electricity generation and 45% by manufacturing and construction (World Resources Institute, 2006).

[i] The United Arab Emirates (UAE) is constituted of seven emirates with a surface area of 83,600 km^2 situated in South west Asia, bordering Oman and Saudi Arabia between the Gulf of Oman and the Arabian Gulf, geographically lies between 22° 50' 26" North latitude and between 51° 56' 25" East longitude. The weather conditions are very hot and semi-arid during summer days becoming warm and humid at night. During winter, daytime conditions fall within the comfort zone, while the night times are cool and humid.

Particularly, the residential sector used 45.9% of the total electricity consumption, due to several reasons including increase in population, and need to leverage comfort levels. In fact, electricity consumption for cooling in buildings in the UAE has intensified ten times (from 5 to 50 Billion kWh) over the past two decades (DEWA, 2003).

For the purpose of this paper, we focus on the status of the residential sector in Abu Dhabi, the capital of UAE, and challenges facing the old stock in meeting recent sustainability standards set by the UAE Government in the form of Estidama[ii] program Design Guidelines. The program has been initiated by a group of government agencies and developers to support the leadership's vision to transform Abu Dhabi into a sustainable Arab Capital. Additionally, the program complements the country's vision for Plan 2030, one that outlines the future urban development of the city of Abu Dhabi. In that sense, we propose a series of strategies to pursue in case of renovating the old housing stock, thus comply with Estidama guidelines, and complement new construction practices.

THE STATUS OF ABU DHABI'S RESIDENTIAL SECTOR

During the Q4-2015, it is expected that the Abu Dhabi residential stock will reach approximately 256,000. In a recent study of Abu Dhabi's property market, only 750 new homes were delivered to the market in 2015. At 2.9% of total housing stock, this represents the lowest level of new residential supply in five years, when average annual population growth has been around 5%. In that sense, it is evident that the residential market is experiencing a shortage in supply to meet the growing demands of the current population, specifically with regard to affordable housing. This has led to significant increase in rents, rising up 7% year-on-year as the current shortage is estimated around 48000 units.

Since the development of Estidama in 2007, around 70,000 residential units were built in accordance to the guidelines and standards set by the Urban Planning Council (UPC). However, the residential stock still includes 185,000 units that were built in the last six decades, prior to Estidama development, thus requires critical examination, then retrofitting to meet with current standards. Accordingly, we strongly believe that retrofitting these units could contribute to the housing market in Abu Dhabi by balancing the gap between supply and demand for high quality housing. The following section describes a set of strategies to upgrade the old housing in order to meet Estidama standards.

STRATEGIES TOWARD A SUSTAINABLE RESIDENTIAL SECTOR

Abu Dhabi Government has taken actions in implementing the Plan 2030 overarching principles and recommendations for the city's future urban development. Over the past few years, UAE has made prominent progress in terms of green building practices, thus leading the sustainability trends amongst the Gulf Cooperation Council (GCC) countries, Middle East and North Africa (MENA) region. For instance, a total of 820 buildings, presenting 70% of the LEED certified buildings in GCC in 2014, were built in the UAE. Other mega sustainable projects producing clean energy have been developed including

[ii] The Urban planning Council (UPC) of Abu Dhabi established the Estidama program Design Guidelines in 2007 to apply to new residential and commercial buildings. It is considered as the Emirati version of the "LEED", being dedicated to ensure sustainable design measures, as well as operation and maintenance of all building types and communities within the Emirates.

concentrated Solar Power and Hydrogen plants in Shams 1 and Masdar city, and PV Solar Electricity in Shams Tower project (Asif, 2015).

As mentioned earlier, in order to achieve the intended healthy environment for Abu Dhabi vision 2030, it is required to upgrade 72% of the existing residential stock. It is assumed that these buildings are highly CO2 generators based on international studies conducted in similar situation. When exploring solutions towards sustainable built environment, the UK could be regarded as a very interesting model. While current efforts are directed towards building new homes and non-domestic buildings on a carbon-neutral basis by 2016 and 2018 respectively, however, the challenges arise in the form of existing buildings. Kelly (2009) concluded that proposing real initiatives is not about replicating precedent small-scale pilot projects, yet emphasized the need of a road map scaled up to serve the entire nation (Building Research & Information, 2009).

Radhi (2009) argued that the main factors affecting energy consumption in buildings can be divided into four categories: climatic effects relating to the micro-climate and location of the building, design effects relating to building design and systems operation, and people effects concerned with the occupants' needs and behavior (Radhi, 2009). Accordingly, there are four ways by which the energy consumption can be controlled:

- Re-engineering the buildings skin with focus on thermal resistance of walls and openings
- Decarbonizing the sources of energy to the home.
- Improving the efficiency of appliances used in the home.
- Educating users to influence personal behavior.

In 2013, The Policy Partners for Eurima published a practical guide for renovation entitled Roadmaps for Buildings. The guide included systematic procedures for renovation of buildings in an effective manner, with focus on specific elements to deliver full potential[11]. Consequently, based on examining precedent studies, we believe that strategies for a long-term retrofit plan would be more effective if tailored to the specific circumstances of UAE, thus adhere to the overarching principles presented in the following sections.

Existing situation overview, assessments and analysis of the old residential stock

Prior to developing strategies, it is essential to conduct a critical analysis of the old residential buildings, with focus on various aspects that affect building renovation options in UAE context. The intended analysis should include the following:

1. Building characteristics, including size, areas, height, and housing typology.
2. Building ownership, including costs and benefits, in detail, for various situations.
3. Co-benefits of energy retrofits
4. Legal requirements for applying buildings renovations
5. Existing policies and programs, and how these are implemented

According to Phdungsilp (2011), development of strategies is typically best served with a combination of forecasting and backcasting. While forecasting is an important tool in the analysis of the status of current trends, and a good starting point for the analysis needed to elaborate strategies, backcasting, on the other hand, starts with defining a desirable future and then works backwards to identify policies and programs that will connect the future to the present. Backcasting encourages searching for new development paths when the conventional paths do not seem able to solve the problem. It provides more suitable approach for developing renovation strategies, since it addresses significant sustainable changes, encourages developing new solutions and interactions between different parties, and then establishes a process of combining long and short-term goals.

When looking at the first step in the evaluation process; buildings characteristics, the world renowned engineering firm ARUP (Connelly, & Adams, 2009) devised a classification model for appraisal of existing buildings based on 5 different categories, and accordingly the required level of intervention as shown in Figure 1. We strongly believe that such a model can be mapped to Abu Dhabi's existing residential stock, by situating each building in its respected level of refurbishment, evaluating the required budget and time to retrofit each building, and finally creating a realistic statement map valid for implementation stage. While level one proposes minor refurbishment, level 5 mandates demolishing the building. We will discuss these strategies in details in the coming sections.

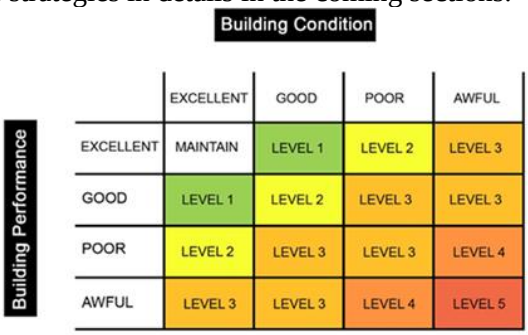

Figure 1. Various levels of intervetion based on the status of existing buildings according to analysis by ARUP

Support a collaborative approach

All parties; government bodies, market actors and stakeholders, need to be consulted at early stage of the development process. The list could include, by not limited to the ministry of public works, Abu Dhabi Municipality, Environmental Agency Abu Dhabi, Mubadala[iii] as an investment and development company supporting the growth of a dynamic and diversified UAE economy, Urban Planning Council, in addition to developers like Al Dar Properties, should play an effective role in the process. In parallel to this development process, the city should invest in programs to advise the public and specialized sector regarding policies and requirements, thus provide support to facilitate the design, commissioning, construction and supervision of renovation works early on in the development process. Moreover, special attention should be given to environmental organizations, industry groups, academia, and professional consultancies.

Develop action plan comprising flexible and creative thinking

Action plan is the result of engagement of all relevant parties. It addresses all issues that are important for their achievements, such as primary policies, standardization and certification, the role of government and market parties, training requirements, and changes in the market structure that are needed to implement the long-term approach. Well-designed action plan should combine ambitious long-term targets with interim goals, qualitatively and quantitatively, and short-term actions. We propose that these plans should have a technological approach for documentation and ease of future developments. On the first hand, renovation models can benefit from the use of prefabricated building components. The physical characteristics of these components and their configuration establish the basis to analyze the capacity of housing designs to accommodate variations requested by users. When looking back at refurbishment levels, we propose the following:

[iii] Mubadala is an investment and development company supporting the growth of a dynamic and diversified UAE economy.

1. Level I - Tune-up and minor refurbishment: including installation of smart control systems in the form of blinds, lighting fixtures, in addition to repainting interior spaces.
2. Level 2 - Intermediate refurbishment: in addition to all level 1 works, revise layout to improve daylight exposure, install solar control devices, and install adaptable systems. This can be done through the use of prefabricated components, including the notion of Open Building Systems developed by Kendell and Teicher in 2000. Such an approach focuses on the application of technology, modern construction techniques, and advanced components as viable strategy to enable flexibility. While the matrix developed by ARUP shows that the retrofitting in level 1 and 2 handle light works which potentially covers the required works to retrofit the buildings of 1990's, in parallel, attention will be given to Estidama requirements to control of water consumption, water leakage, water supply protection, and water efficient landscaping. For the energy use, attention will be given to the energy metering, internal and external lighting, hot water supply, lifts, cooling and air condition, energy efficient appliances, on site renewable energy generation.
3. Level 3. Major refurbishment: Replace major technical components and services.
4. Level 4. Complete refurbishment: Retain only the substructure, superstructure and floor structure, then undertake structural and façade alterations, and consider relocation of cores and risers.
5. Level 5. Demolish and rebuild.

In order to prepare the building for any future iterations, we recommend applications of Digital Prototyping[iv] tools to empower post-occupancy adaptability, with the aim of responding to prospective changes in socio-demographic characteristics of occupants. Digital Prototyping would allow for digital documentation of any refurbishment, which means that it can be recorded in a digital format using advanced software platforms, thus facilitate using data in the future.

Stimulating financial mechanisms to support renovation plans

Devising effective financial mechanisms is considered crucial especially for deep renovations. It comprises providing support to facilitate the design, commissioning, construction and supervision of renovation works, and purchase/installation of components. Soft loan programs or other forms of financial support should be made available in conjunction with other measures, so that funding is available when building owners are encouraged or required to invest. Many financial instruments have been applied successfully in Europe and USA and could be applicable to the building sector in Abu Dhabi (EuroACE/Klinckenberg, 2010). Figure 2 represents a timeline of applying the proposed strategies and its impact on the existing residential stock.

[iv] Within the engineering and design realm, Digital Prototyping is defined as the mean by which engineers, and designers can explore products virtually before being built. It allows for designers to validate, simulate, optimize, and visualize products data throughout the product development process within an advanced a digital environment.

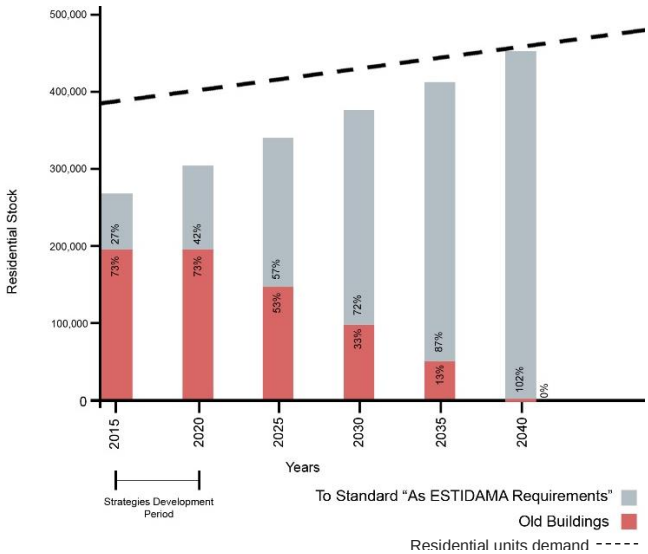

Figure 2. Milestones in application timeline of the proposed strategies

IMPLEMENTATION AND CONTINEOUS EVALUATION

The implementation of the action plan to execution, as shown in figure 2. should go through some steps that include data gathering from all participants, annual progress report prepared by leading organization and approved by steering group. In parallel to the implementation, an annual evaluation of progress vs. targets, energy savings achieved and adaptations needed to action plans will be undertaken. Recommendations to improve the approach as needed in order to achieve the targets of each mile stone.

Figure 3. Diagram representing process of implementing the proposed strategies.

REFLECTIONS

Prior to devising strategies, it is required to develop a clear distinction between a refurbishment and a retrofit. According to reports by the Council on Tall Buildings and Urban Habitat (CTBUH, 2012), following 25 years of building operation, the performance of building equipment, facades and finishes may have diminished to a point where the building needs investment to maintain its original performance. If the original performance is restored, then a refurbishment has been undertaken, but if additional

functionality is added, a retrofit has been performed. Both operation lead to great commercial success, yet retrofitting has greater sustainability success of outcomes.

Abu Dhabi old residential stock is responsible for a significant proportion of our CO2 gas emissions. Estidama program proposed by Abu Dhabi government as a sustainable regulatory tool for all new construction should meet the expectations of green cities in the emirate of Abu Dhabi but adopting other survival strategies to retrofit the old existing buildings stock. Proposing new strategies for old Buildings that do not fulfill current expectations in term of sustainability and economics.

We propose an ambitious long term strategies that brings together different parties to the process, including the owners, the tenants and the community in large. As a first step of a long term innovation plan spreaded on twenty years, a detailed assessment of the old buildings conditions will be necessary to identify the areas that need improvement and the level of retrofitting. Architects and engineers have many tools to perform such analysis on building structure, envelope, energy, water consumption and supply, waste management, and facilities management.

Defining goals and targets to establish a successful action plan is the base of the proposed model, which does not target to create "near zero energy" buildings but aims to extend old buildings to a high energy performance level. Based on the pace of development in the city, we believe that a range of four years of buildings assessment and setting up the action plan development, then twenty years to implement the proposed action plan seems to be realistic and complies with the cadence of the construction development in the city.

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