

Sustainable High-rise Design Trends – Dubai’s Strategy

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Abstract Until recently, the construction industry in Dubai was the creator of unsustainable world breaking high rise towers. This approach led to Dubai becoming labeled as the largest polluter in UAE and seen by the construction industry worldwide as an example of an unsustainable city. The current global crisis, however, has provided Dubai with the opportunity to firstly understand the benefits of sustainable practice and then implement this concept strategically within the construction industry. This study aims to identify the prototype for sustainable high rise design trends for the future by examining whether the future high rise towers align with the Dubai Government’s strategy based on a number of case studies. It is within this context that this research generates a discussion regarding the Dubai Government Strategic Plan (2015) in conjunction with the recently revised green building rating system BREEAM Gulf and establishes that sustainable high rise buildings are being promoted throughout these strategies. Furthermore, this research presents case studies which discuss the future high rise functional use trend, the Burj Dubai / Nakheel Tower and the Dynamic Tower, leading to a determination being made that these projects align with the Dubai Government’s strategy. It is highly recommended that the future prototype should be mixed-use, respond to the growing needs of the economy, and achieve the highest possible energy rating. Future research directions have also been pinpointed.

Keywords Sustainability, High-Rise, Design Trend, Green Building, Dubai

1. Introduction

Awareness of the diminishing oil reserves in Dubai has led to drastic measures being made by the Dubai Government to diversify their economy [1]. This resulted in a focus on tourism, business and trade, which required an unprecedented government commitment and investment, to

ensure the success of this strategic decision [2]. Numerous strategies were employed by the Dubai Government to stimulate the economy and therefore achieve their new objectives. These included the construction of the first seven star hotel in the world - Burj Al Arab, free business zones being made available to global companies and the opportunity for foreigners to purchase real estate [3]. Jana [4] describes this directional change as a period of time where Dubai was seeking to achieve world records; having the tallest, largest and when possible, the first of everything.

However, the global financial crisis has prevented Dubai from continuing construction at this phenomenal rate. Smith [5] highlights the fact that Dubai is \$80 billion in debt, which is preventing the opportunity to inject large amounts of money into the economy. Harman [6] further exemplifies this matter highlighting large projects, such as the \$600 million Trump Towers, has been suspended with a commencement date unknown. Furthermore, Murray [7] raises issues regarding newly built high rise towers, which have insufficient surrounding infrastructure, such as pedestrian access and in some instances no electricity supply.

Interestingly, Lachenmayer [8, p.19] raises the importance of the current global crisis. He explains it ‘can be seen as a blessing in disguise for Dubai.’ Lachenmayer [8] explores this idea further by noting during strong periods of growth clients / investors get held up in the concept of making record profits and avoid the real issues at hand. Therefore, this provides the opportunity to evaluate and strategically plan for the future, by learning from the mistakes made in the past. This notion has been observed by Murray [1] in Dubai; ‘clients have begun asking for high quality, sustainable buildings, not just iconic, world record-breaking structures.’

Worldwide the construction industry uses 60% of the world's energy to heat, light and ventilate buildings [9]. Major contributors to this statistic are energy hungry high rise buildings in Dubai. Prior to the worldwide economic crisis, Dubai was striving to break as many records as it could in terms of the tallest, largest, or simply the first [4]. In recent times, the Dubai Government has identified the

importance of sustainability and in doing so has realised that in order to make Dubai a world-class city in a true sense – the biggest polluter to the UAE’s environment, the construction industry should be regulated [9]. This issue has been addressed in Dubai’s Strategic Plan (2015) within the five guiding principles, in particular the ‘Infrastructure, Land and Environment’ principles and also with the BREEAM Gulf environmental assessment system.

Dubai’s Strategic Plan (2015) presents the Government’s vision and framework regarding how this is going to be achieved, however gaps appear in current research with reference to whether the future high rise design trends align with these principles. Research by professionals within the construction industry, have reviewed proposed future high rise projects in Dubai from a sustainability point of view, but failed to identify whether these design trends align with Dubai’s Strategic Plan (2015). Further to this, no existing research presents a recommended high rise design trend for Dubai to employ. This presents a number of issues because in order for the Dubai Government to achieve these objectives and therefore be seen globally as a sustainable city, all governing bodies need to have a clear understanding of this Strategic Plan. This will ensure future high rise design trends not only meet these minimum standards, but the construction industry is encouraged to exceed these standards where possible. To achieve this objective a high rise design trend benchmark needs to be established, to allow a comparative analysis to occur.

This paper attempts to address the gap in current research, by providing justification as to whether the future high rise buildings align with the Dubai Government’s strategy and to identify the most appropriate sustainable high rise design trends. The primary objectives of this paper include (1) investigate the problematic issues in the past methodology which Dubai adopted within the construction industry and how these issues can be mitigated in future projects; (2) examine the significance of sustainability to high rise building design trends; (3) explore how the five guiding principles of the Dubai’s Strategic Plan (2015) will influence high rise building design trends; (4) explore how the BREEAM Gulf environmental assessment system will significantly influence high rise building design trends; and (5) analyze influential high rise towers in Dubai, which are currently or proposed to be built. After the introduction, this paper will review the literature on sustainable practice. It will then review the Dubai Government Strategy towards Sustainability in detail, followed by case studies of Dubai high rise buildings. A detailed discussion will be presented before concluding remarks and recommendations for future research.

2. Literature Review

2.1. Sustainable High Rise Buildings

Within the construction industry there is still much

confusion regarding what sustainability is. This is partly due to the fact that there is generally a lack of knowledge amongst professionals that sustainable practice is not financially rewarding. However, through a greater understanding of the benefits of implementing sustainable principles, this perception has caused many in the construction industry to re-evaluate their ethical and moral stance in seeking innovative pursuits with eco-effective results in mind.

Sustainability has many definitions but the basic principles and concepts remain constant: balancing a growing economy, protection for the environment, and social responsibility, so they together lead to an improved quality of life for ourselves and future generations [10, p.31]. Crompton and Wilson [11, p.3] explore the concept of sustainability further by providing a purist’s definition of a sustainable tall building; ‘one which emits no pollution to air, land and water, and can be economically occupied throughout its design life, whilst contributing positively to the local community.’ Galbraith [12] raises the viewpoint that for the construction industry this purist’s objective of sustainability is not feasible, however, encourages the industry to incorporate sustainable design where possible and in doing so have an understanding of how the building will impact the environment in both a positive and negative way.

In order to create a platform which allows innovative change and sustainable development, a series of basic principles need to be established. Material choice, orientation of the building to maximize solar gain, and a cradle to mentality in the way we build and manufacture building products, should all be employed as standard practice.

There are many benefits for clients, developers and owners in incorporating sustainable practice into a construction project. These benefits include significant reductions in green house gas emissions [13], increase in productivity by at least 30% [14], 5 to 10% reduction in cooling needs [15], a saving on average, 70% of electricity, between 50% and 60% of water, and 36% of energy when compared to the standard buildings [9], 30% reduction in light fixtures or light needs - critical when you consider that lighting can account for up to 35% of a building’s energy and financial gain by commanding sale prices of 30% more on average when compared with other buildings[15].

2.2. Implementing ‘Green’ Objectives in Future High Rise Buildings within Dubai

To successfully implement green objectives in high rise buildings ‘a strong understanding of existing conditions: environmental data, relationship to existing and future developments, and the policies in place that support site development’ [15] must be achieved. Gill [15] further details this process stating ‘designers must understand and consider building orientation, opportunities for daylighting, generation of wind power, solar absorption and a site’s

geothermal properties.’ Jahnigen [16] summarizes this concept convincingly by suggesting ‘there is no ‘one-size-fits-all’ approach, as the development of a project is unique based on its surroundings.’

In reference to Dubai, one of the climatic conditions which must be identified and designed around includes the extreme heat where ‘temperatures in summer average forty-five degrees, while in winter they fall to 24 degrees’ [17]. Consequently, ‘ninety-five percent of all spaces [are] air-conditioned,’ [17] to try and provide comfortable working conditions inside. Conradi [18] identifies that this climatic condition needs to be considered at the forefront of the design phase and identifies the opportunity to exploit this, by incorporating solar panels to generate electricity that can be used within the building.

3. The Dubai Government Strategy towards Sustainability

3.1. Introduction

In the past decade, sustainable design and practice was not identified by the Dubai Government as a means for innovative and profitable outcomes [19]. This was largely due to the fact that clients, consultants and contractors were experiencing a period of substantial growth and stability in the construction industry. The mentality was simply to construct high rise buildings rapidly to try and meet the excessive demand by wealthy expatriates who were seeking instant profits and a life of luxury. Hence, sustainable practice was at best an afterthought, which was seen as an unnecessary expense for the client to invest in [20].

However, the recent global crisis has put enormous strain on the city of Dubai, which has been forced to seek alternative approaches to stay insulated during these tough times. A collaborative approach seeking innovation through sustainability has recently been understood and acknowledged to produce positive outcomes, not only the client and project team, but also the occupants of the building. This understanding has been presented within the Dubai Strategic Plan (2015) and also in the BREEAM Gulf environmental rating system for construction professionals to adhere to.

3.2. Dubai Strategic Plan (2015)

The Dubai Strategic Plan (2015) was announced by His Highness Sheikh Mohammad Bin Rashid Al Maktoum, UAE Prime Minister and Vice President, and Ruler of Dubai, on the 3rd of February 2007. This document details the strategic approach to develop the emirate's most dynamic economic sectors and was launched by His Highness Sheikh Mohammad Bin Rashid Al Maktoum under the theme of ‘Dubai...Where The Future Begins’. Maktoum [21, p.9] clearly presents within the Dubai Strategic Plan (2015) the aim, which is ‘to establish a universal understanding of

Dubai’s vision among the various government entities and to ensure a common framework for the operations of these entities.’

In order to achieve this aim, five guiding principles have been identified within the Dubai Strategic Plan (2015), including (1) Economic Development, (2) Social Development, (3) Infrastructure, Land and Environment, (4) Security, Justice and Safety, and (5) Government Excellence [21]. The guiding principle which addresses sustainable development is the Infrastructure, Land and Environment. The aim of this guiding principle is ‘to ensure proper focus on sustainable development within the context of Dubai’s considerable economic growth’ [21, p.32].

In order to further explore and detail this guiding principle, four strategic trusts, which outlines how this vision will be achieved, have been presented, including (1) Optimize land use and disruption while preserving natural resources, (2) Provide efficient energy, electricity and water supplies to meet Dubai’s growing needs, (3) Provide an integrated roads and transportation system to facilitate mobility and improve safety, and (4) Maintain Dubai as a safe, clean, attractive and sustainable environment [21, p.33]. Within each of these strategic trusts, the document further details these and highlights the requirement to optimize land use, secure both in the short and long term natural resources, develop the transport infrastructure, continually update green building regulations and promote sustainable practice.

3.3. New Green Building Rating System for Construction in Dubai

Until recently, the only green building rating system used in Dubai was the US Green Building Council’s (USGBC) LEED certification. However, this new acknowledgement regarding the importance of implementing sustainability has resulted in, ‘BRE Global [launching] BREEAM Gulf, a regional adaptation of the UK standard’ [22]. The aim of BREEAM Gulf aligns with the UK standard, which is to identify the various building types and following this allow assessors the right framework to evaluate the building’s environmental credentials [23]. This assessment can occur during the design stage and/or during the post-construction stage and can be undertaken for new buildings, major refurbishments and new build extensions [24].

In contrast, BREEAM Gulf ‘evaluates the performance of a whole building taking into account the different uses’ [23] such as commercial and residential use. The significance of this is to reflect on the common building types in Dubai, which is mixed-use. BREEAM Gulf contains the same categories from the UK BREEAM which includes Management, Health and Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use and Ecology and Pollution [24]. Within each of these categories, numerous criteria’s are assessed via rating benchmarks and environmental weightings, to determine a section’s score, which when added together provides a total score [24]. This total score then indicates a star rating, which reflects how

environmentally friendly the building is. An example of the BREEAM Gulf rating benchmarks along with the score and rating calculation is shown in Table 1 and Table 2.

Table 1 BREEAM Gulf Rating Benchmarks [24]

BREEAM Rating	% score
No stars	<30
•	≥30
• •	≥45
• • •	≥55
• • • •	≥70
• • • • •	≥85

Table 2 BREEAM Gulf Score and Rating Calculation [24]

BREEAM Section	Credits Achieved	Credits Available	% of Credits Achieved	Section Weighting	Section score
Management	7	10	70%	0.08	5.60%
Health & Wellbeing	11	14	79%	0.15	11.85%
Energy	10	21	48%	0.14	6.75%
Transport	5	10	50%	0.05	2.50%
Water	4	6	67%	0.30	20.1%
Materials	6	12	50%	0.09	4.5%
Waste	3	7	43%	0.05	2.15%
Land Use & Ecology	4	10	40%	0.07	2.8%
Pollution	5	12	42%	0.07	2.94%
Total Score				59.19%	
BREEAM Rating				• • •	

Upon review of the BREEAM Gulf score and rating calculation, the water section is weighted the heaviest at 30%. Standen (cited in Hartman [22, p.36]) emphasis the significance of water to the area by explaining ‘most portable water in the Gulf is provided through the desalination of sea water, a process which (...) is 10 times more energy intensive than providing a litre of water in the UK.’ Furthermore, the other heavily weighted categories; health & wellbeing – 15% and energy – 14%, will also significantly influence the high rise design trend prototype and therefore must be considered at the forefront during the design phase of a project. Willis (cited in Hartman [22, p.35]) reflects on both rating systems and suggests that ‘both rating systems are doing the right thing, which is to reduce energy loads in buildings.’ Others however, may argue that BREEAM Gulf should be Dubai’s preferred rating system because it addresses ‘the region’s climate, regulations and construction practices’ [22].

3.4. Further Discussion

Dubai, until recently, has experienced unprecedented

levels of construction and consequently energy hungry and sick buildings have been built. In contrast today, sustainability has been considered at the forefront during the design phase of projects. Lander, Head of Sustainability at Atkins Dubai, reiterates this notion further by stating the sustainability agenda has ‘exploded’ in the last six months [22, p.35]. Johnson, a Gensler Managing Principal further strengthens this viewpoint commenting Dubai is picking up on messages from around the world, and one of those is sustainability, and they have the ability to implement it. However, research conducted by Marashi and Bhinder [9] has identified that the real challenge lies in integrating this growth and development with sustainable solutions that have long-term effects.

4. Dubai High Rise Building Case Studies

High rise buildings consume large amounts of energy. They are the most influential type of structure, due to their size and function and consequently must be seen by the construction industry as the platform where sustainable design must be showcased [25]. In this section, three case studies are presented in an analytical approach to examine and understand Dubai’s strategy towards sustainable high rise design trends in the construction industry. Case study No. 01 examines the functional use design trends in high rise buildings used today and identifies which type is most commonly used. Case study No. 02 outlines how high rise building design trends have continued to develop allowing greater heights to be achieved. Case study No. 03 presents a world breaking sustainable high rise building concept, which will influence high rise design trends worldwide.

4.1. Case Study No. 01 - Future Functional Use Trend

High rise towers can be classified into three functional use categories; commercial, residential and mixed-use. Binder [26] states that the mixed-use tower is now replacing the typical corporate office tower. This evolution has been reiterated by the Council on Tall Buildings and Urban Habitat (CTBUH) following research conducted which illustrated on the tallest 100 buildings lists from 1930 to 2000 [27]. The percentage of office towers was never below 86% whilst down to just 46% by 2010 [27].

Binder [26] suggests that this evolving trend may be a result of the enormous levels of construction which has occurred recently, leading to a shortage of tenants to fill commercial high rise towers. Furthermore, Binder [26] explains tourism is fast becoming an influential economy as hotels are becoming the major tenants of the new millennium. Research conducted by Gill [15] identifies the potential within mixed-use towers to foster a symbiotic relationship between different programme elements, while the office space demands the heaviest energy load during the day, the hotel’s usage is heaviest at night. Gill [15] explores this

concept further by identifying through the use of an 'intelligent energy system' automatic programming can occur, ensuring that air-conditioning is only provided to those spaces which are occupied. This will result in an increase in the tower's energy efficiencies, along with balanced communities that work in symbiosis with one another.

Samarai and Qudah [14] extend upon Gill's understanding identifying the aim of mixed-use development is to have a community that is self-serving without the need to go anywhere else for anything. People will live, work and play all in the same place. High rise towers currently under construction in Dubai are predominately residential and mixed-use types. An example of a residential tower is the Pentominium Tower, which is set to become the 'the tallest all residential building in the world [at 615 metres], and is configured to provide one owner per level over its 120 occupied upper levels' [28]. The current most influential mixed-use tower examples are the Burj Dubai, its adherent the Nakheel Tower and also the Dynamic Tower.

4.2. Case Study No. 02 - Tallest Building in the World

4.2.1. Burj Dubai

The tallest building in the world currently is the Burj Dubai, which has been completed recently. This mixed use tower contains retail, offices, residential apartments, and a hotel and seeks to exhibit Dubai's vision to set world benchmarks within the construction industry. In making this project a reality, one of the critical issues the design team had to resolve was regarding how to reduce and control the wind forces on the tower. The design team's solution to this issue was a tri-axial 'Y'-shaped plan, where each tier of the building sets back in a spiral stepping pattern up the building (see Figure 1). This concept allows the facade to 'confuse the wind' because the wind vortices never consolidate with one another, due to the evolving building facade [29]. This shaped floor plan has other advantages such as providing 'an ideal arrangement of residential units, having an optimal plan depth-to-perimeter ratio and allowing maximum views outward, without overlooking a neighboring apartment' [30].

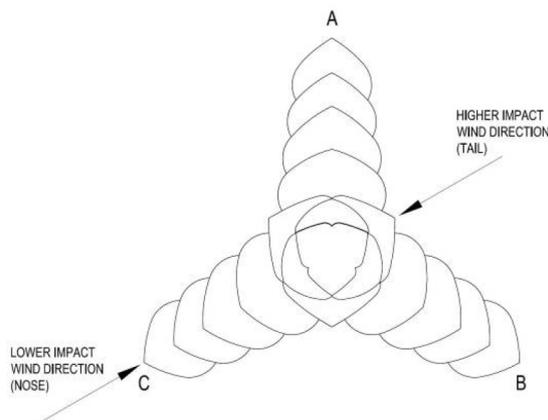


Figure 1. Burj Dubai Floor Plan [29]

4.2.2. Nakheel Tower

The adversary of the Burj Dubai, which will claim the world's tallest building when completed in the near future is the Nakheel Tower, which will stand over one kilometre tall. Unlike Burj Dubai, the design team for the Nakheel Tower is aspiring to achieve LEED Gold rating via numerous ESD initiatives, and in the process challenges the current model of what a sustainable tower should encompass, whilst providing the industry with the perception that the sky is the limit [31]. Achieving this world breaking height resulted in further research and analysis being undertaken, based on the lessons learnt from the Burj Dubai, along with the implementation of innovative sustainable principles. The design concept employed involved separating the tower into four stand alone towers, which were connected via skybridges at every 25 levels. Therefore, wind could pass through the building allowing the typical tampering of high rise tower floor plates was avoided (see Figure 2). This sustainable solution provides larger than normal floor plates at the upper levels, resulting in greater return in investment being achieved.

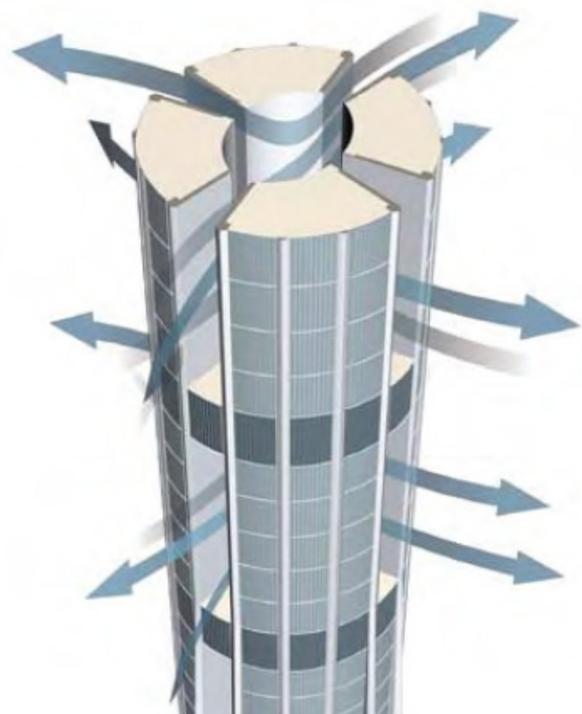


Figure 2. Perspective view of the Nakheel Tower illustrating how the wind passes through [31]

In further comparison to Burj Dubai, the Nakheel Tower also contains retail, offices, residential apartments and a hotel, however, further to this also contains an experience centre and observation facilities along with a special sky function space – creating a vertical community of over 15,000 people (see Figure 3). This new concept of sky bridges serves multiple purposes such as providing community and public spaces where visitors and residents alike can interact, whilst joining the four separate towers together and allowing transfer points between lifts [31].

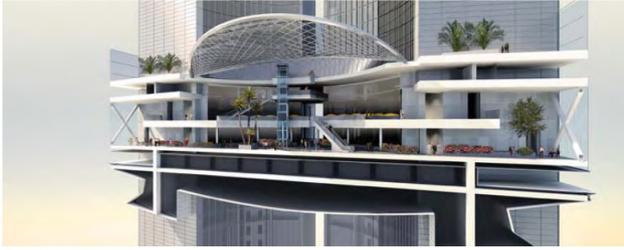


Figure 3. Nakheel Tower Sky Bridge Section [31]

4.3. Case Study No. 03 - World Breaking ‘Sustainable’ Design Concept

Pioneering architect Dr Fisher from the Florence based Dynamic Architectural Group, has created a world breaking concept involving a high rise tower’s facade, which constantly rotates (see Figure 4). The Dynamic Tower is 80 floors high and is a mixed-use development containing offices, residential apartments and a hotel. This construction procurement method is unique to the construction industry as it will be the first factory-built skyscraper [32]. It will be made possible by constructing only the building’s central core on site, which contains the buildings vertical transport system and services, while the remainder of the structure is prefabricated in a factory in Italy [33]. Each apartment is integrated within a prefabricated module, which is completely fitted out and only requires owners to move their furniture in [32].



Figure 4 Dynamic Tower Rotating (Fisher [34])

Chamberlain [33] highlights some advantages of this procurement method stating designers estimate that the prefabrication approach should cut construction time from 30 months (for a traditional build) to 18 months. Furthermore, an estimated 90 employees will be required on site and an additional 700 employees in the factory, in comparison to over 1,000 employees for a typical project of this size on site [33]. However, although these factors present potential cost savings for the project, it is believed the tower in Dubai will cost around \$330m. This significant cost can somewhat be justified by the investment in advancing today’s technology

in high rise developments, whilst ensuring a sustainable concept is projected. Fisher further discusses this issue stating the Dynamic Tower will be so energy efficient it will have enough surplus to power five similar-sized buildings [34]. This is achieved by large photovoltaic cells installed on the roof, along with 48 carbon fibre wind turbines which are positioned between each of the 80 levels [33].

Chamberlain [33] analytically raises a number of possible problematic issues regarding this design concept. Firstly, as the tower constantly rotates how can a reliable power and water supply be provided? Robertson (cited in Chamberlain [33]) who is the structural engineer for the project, explains supplying power to the apartments is based on ‘the (...) same [principle] as that of a moving train gathering power from a third rail or an overhead line (...) [and] many appliances (...) [will] get power wirelessly. Furthermore, Robertson (cited in Chamberlain [33]) explains water supply will be provided through a sprinkler system via a ‘flex connector, like a fire hose, and (...) [occupants] will plug it in when (...) [they] want to take water in.’ In summary, Fisher [34] claims that the Dynamic Tower is the ‘first real green building’ because no building before has been designed to produce much more energy than it can use.

5. Discussion

Development in Dubai prior global economic crisis was occurring at unprecedented levels, which Abdellatif (cited in Marashi & Bhinder [9]) comments was ‘too fast for Social Structure, too fast for Infrastructure, too fast for the people, too fast for the environment and too fast for (...) [Dubai] to learn from (...) [their] mistakes.’ This has resulted in Dubai adopting a more sustainable approach ensuring that future generations understand and therefore continue to implement sustainable development.

5.1. Critical Analysis of the Dubai Government Strategy

For any city worldwide ‘taking up the cause of sustainable development is a big task, which requires vision, sound plans and most of all commitment at all levels’ [9]. The Dubai Government has certainly taken important measures to implement sustainable development by detailing this approach within the Dubai Strategic Plan (2015) under the section Infrastructure, Land and Environment and also by encouraging the use of environmental rating systems LEED and the newly created BREEAM Gulf. Another implementation included the formation of the Emirates Green Building Council in 2006. The success of this congress was reiterated by Seneviratne (cited in Hartman [22]) who claims ‘almost 1,000 engineers, architects and other construction professionals in the UAE have trained as LEED (...) [accredited professionals] (...) [during 2007 – 2008].’ Along with this initiative a number of ‘free zones have adopted LEED Silver or Gold as a minimum standard for development’ [22]. However, this is yet to be

implemented for BREEAM Gulf.

Marashi and Bhinder [9] interestingly suggest that the Dubai Government has the precise framework in place to achieve sustainable development and accordingly it is now the responsibility of the relevant committees, clients, developers and consultants to ensure this is made a reality. This viewpoint can be challenged upon close review of the Dubai Strategic Plan (2015). Critics would question why the Infrastructure, Land and Environment guiding principal is not presented first, ahead of both the Economic Development and Social Development guiding principles. By presenting this section first, it illustrates Dubai's commitment of prioritising sustainable development to achieve both economic and social development. Further analysis of the Infrastructure, Land and Environment guiding principal section uncovers universal aims, such as 'maintain Dubai as a safe, clean, attractive and sustainable environment' Maktoum [21, p.32]. Furthermore, this aim could have included measurable objectives outlining a percentage of annual carbon emissions targeted, along with the enforcement of a minimum environmental rating for both the LEED and BREEAM Gulf applied to all new construction.

Maktoum [35] presents a similar argument against Marashi and Bhinder emphasising the importance of constantly reviewing the Dubai Strategic Plan (2015) to ensure this aligns with the current economic conditions. It is pointed out that due to the global financial crisis, the Dubai Government is in the process of reviewing all the developments in the financial markets and the global economy and will revise Dubai's Strategic Plan accordingly [35]. This strategy will ensure that where required, the objectives and timelines contained within the Dubai Strategic Plan will be adjusted to ensure these are obtainable.

5.2. Future High Rise Design Trend Recommendation

High rise towers of the future must not merely be measured by total height, instead its efficiency and impact on the environment will indicate how successful the development has been [30]. Research carried out to date, indicates how future high rise design trends will encompass the mixed-use prototype. This works in unison with Dubai's urban planning scheme involving creating 'cities within a city' [14]. Projects such as the Burj Dubai, the Nakheel Tower and the Dynamic Tower all attempt to exemplify sustainable development and achieve varying levels of success. Hence, analytical criticisms of each of these developments can be made to further understand the future high rise design trend Dubai should be inspiring to.

Weismantle *et al.* [30] question whether 'the Burj Dubai [is] an evolution based on designs that have come before it, or is it a revolution in design, more significant for more than just its unprecedented height?' Most critics would agree that it is both because extensive research has been undertaken to allow this concept to be developed and made possible, whilst challenging the industry to further develop this prototype.

The Nakheel Tower successfully attempts to challenge the world breaking achievements made by the Burj Dubai. Innovative sustainable practices have been employed, which reduces its carbon footprint. The matter which was not discussed in any of the research papers published was the fact that a tower of this nature and size can only be attempted occasionally. Enormous investment is required by developers, which must be validated by market interest and investment. A LEED platinum rated high rise tower will not be seen as a sustainable solution, if the tower is occupied at 40% capacity.

Furthermore, the Dynamic Tower presents an arrangement of sustainable initiatives never attempted previously. Whilst adopting this strategy, new questions need to be asked and consequently answered by the Dynamic Architecture Group. How reliable will the wireless power supply be during desert storms? How environmentally friendly is transporting these apartment capsules from Italy?

In review, all three prototypes; the Burj Dubai, the Nakheel Tower and the Dynamic Tower align with the Dubai Strategic Plan (2015), in particular, the guiding principle - Infrastructure, Land and Environment. Each development provides community facilities, promotes sustainable practice, exhibits energy efficient solutions, optimises land use and reduces strain on the existing transport infrastructure [21, p.33]. As discussed, each of these prototypes has issues which require to be addressed. Accordingly, Dubai has not discovered their high rise model which reflects the high rise design trend of the future. This can be achieved in the near future through evaluating and further developing the existing design trends proposed today. Based on research conducted to date, the future prototype should be mixed-use, achieve the highest possible energy rating (LEED or BREEAM Gulf) and 'reduce the human impact on the environment' [31].

6. Conclusion and Recommendations

The current global economic crisis has led to individuals, companies and governments to consider innovative approaches to secure their position within the construction industry. With the recent uncertainty as to the full impact of the global economic downturn, the construction industry in Dubai is being forced to consider more than just profitability, but to also establish a response which increases activity strengthening the economy. This has been achieved by setting clear and distinct objectives and values, to ensure all members of the industry remain focused during this difficult period. A newly adapted rating system BEEAM Gulf has been released and currently the Dubai Strategic Plan (2015) is being revised to further detail Dubai's strategy towards sustainable development in these challenging times. By establishing these principles, members within the industry can contribute their knowledge and energy toward[s] creating a prototype for greening tall buildings'. This future high rise design trend will encompass a sustainable mixed-use approach, which responds to the growing

demands of the economy through the implementation of intelligent ESD initiatives, resulting in a ‘green’ high rise tower solution.

Further research could examine sustainable high rise design trends outside of Dubai and determine whether Dubai can implement some of these sustainable practices, to further improve their sustainable high rise prototype. Additional research methodology could be employed to obtain additional primary data via a questionnaire which would be completed by professionals in the construction industry. These results would be populated and allow further discussion to take place and refinement of Dubai’s sustainable high rise prototype.

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