From Smart-Eco Building to High-Performance Architecture: Optimization of Energy Consumption in Architecture of Developing Countries

M Mahdavinejad¹ and N Bitaab ²

1 Associate Professor, Department of Architecture, Tarbiat Modares University, Tehran, Iran
2 M. Sc. Student, Department of Architecture, Tarbiat Modares University, Tehran, Iran
E-mail: mahdavinejad@modares.ac.ir

Abstract. Search for high-performance architecture and dreams of future architecture resulted in attempts towards meeting energy efficient architecture and planning in different aspects. Recent trends as a mean to meet future legacy in architecture are based on the idea of innovative technologies for resource efficient buildings, performative design, bio-inspired technologies etc. while there are meaningful differences between architecture of developed and developing countries. Significance of issue might be understood when the emerging cities are found interested in Dubaization and other related booming development doctrines. This paper is to analyze the level of developing countries’ success to achieve smart-eco buildings’ goals and objectives. Emerging cities of West of Asia are selected as case studies of the paper. The results of the paper show that the concept of high-performance architecture and smart-eco buildings are different in developing countries in comparison with developed countries. The paper is to mention five essential issues in order to improve future architecture of developing countries: 1- Integrated Strategies for Energy Efficiency, 2- Contextual Solutions, 3- Embedded and Initial Energy Assessment, 4- Staff and Occupancy Wellbeing, 5- Life-Cycle Monitoring.

1. Introduction
Why energy conservation is important? It is one of the most challenging questions regarding to contemporary architecture of developing countries such as Iran. [1] Cultural issues have a lot to do with architecture [2] not only in form and shape but also in architectural design process and strategies. [3] In recent trends in contemporary architecture of developed countries, more than ever, new technologies have dominated and future architecture might be seen from the viewpoint of high-tech developments. It is very important to explain that future legacy in architecture is in need of smart contribution towards technology. [4] Developing a new paradigm for performance of recent theories in emerging cities is depends on eco-friendly development as well [5] especially in advanced mega-cities. Future architecture and new technology are two inseparable phenomena. Looking back to traditional architecture oriental countries shows that ecology has a lot to do with architecture as well. [6] Therefore in order to meet future legacy in architecture, it is essential to find a biophilic trends towards technology. [7] Shifting to parametric program for development and contemporization of indigenous and intelligent pattern might be seen as a way to sustainable architecture. Smart materials, recombinant nano-structured smart materials, recently developed hybrid technologies, biophilic recycled materials etc. [8] have made a meaningful changes in our perspective regarding to the future
sometimes promising and sometimes threatening [10]. It might be concluded that there are no chance for future architecture unless via interaction of nature and technology.

2. Literature review

Energy efficient architecture and planning is going to a dominant paradigm for future architecture. There are considerable numbers of researches regarding to significance of understand historic buildings and traditional architecture oriental countries through energy efficiency perspective [11]. Literature review of the paper show that meaningful number of researches concentrating on searching for sustainable building technology and urban development, energy technology and policy [12] and its essential criteria such as shape and form, air pressure, natural ventilation wind flow, thermal comfort and indoor temperature [13]. Optimisation of building shape and orientation for better energy efficient architecture [14] in one hand; and searching for flexible approach to architectural design as a tool for achievement eco-friendly buildings [15] in other hand, brought a new atmosphere to state of the art of the issue.

The concept of sustainability in contemporary architecture and its significant relationship with vernacular architecture [16] seems to be a secure way to sustainable development. Traditional architecture oriental countries is a scene to find invaluable samples of natural ventilation efficiency [17] Architectural application of new materials and flexible formworks [18] for architectural design process, besides reunderstanding the role of vernacular architecture in sustainable design [19] while adopting recombinant materials in contemporary energy efficient architecture [20] and search for smart solutions for innovative architecture [21] might be seen as a way towards regenerative environments for future. Recent trends concentrated on passive and low energy architecture, zero energy development for cities, buildings and societies.

3. Theoretical framework

From raising idea of “innovative technologies for resource efficient buildings” to latest developments in computational CFD approaches towards zero-energy architecture; there are considerable number of researches regarding to meet high-performance architecture and planning. It is a controversial issue to imagine characteristics of future architecture while there are meaningful differences between architecture of developed and developing countries. In emerging cities like Dubai and other Dubaiization followers in developing countries, there is influential shadow of technology-oriented concepts for contemporary architecture of developing countries. Formal document of “Smart-ECO buildings towards 2020/2030: innovative technologies for resource efficient buildings” [22] might be as basis to understand concept of smart-eco building. In other words, “Sustainable Smart-ECO Buildings” might be understand as an integrated energy and architecture design (IEAD) [23] as a holistic design applying innovative technologies. [24] It seems that green eco architecture as mentioned by JOSE/SEBASTIAN RICCIARDI [25] might be seen as a goal for green strategies for development of smart-eco buildings. Although sustainability of buildings has been studied for a long time, there is no universally accepted definition of a “sustainable”, “ecological”, or whatever definition may be used, buildings. According to the resulting vision, a Smart-Eco building in 20 years should:

- Be designed from a lifecycle point of view
- Be constructed with limited resources and minimized energy consumption and waste production
- Have minimized operational complexity while allowing easy monitoring of technical and environmental performances
- Be adaptable to changes in capacity, type of users and performance requirements
- Include local issues in all aspects of design construction use and dismantling
- Facilitate ease of dismantling – reuse, recycle, restore. [22]

Other related issues to sustainable development such as economic sustainability has a lot to do with energy [26] and efficiency in energy audit in architectural performance.
Recent researches are focused on efforts to make buildings smarter in order to overcome interoperability problems to assert control over our buildings such as offices, hotels and airports while cutting costs by streamlining building operations like air conditioning and lighting. [27] Theoretical framework summarized based on holistic viewpoint are ranked as 1- Technical Performance, 2- Economic, 3- Sustainable, 4- Regional Pre-conditions and 5- Social.

4. Methodology
This paper is to analyze the level of developing countries’ success to achieve smart-eco buildings’ goals and objectives in case of emerging cities of West of Asia those are selected as case studies of the research.
Ten buildings selected randomly from among recently acclaimed buildings in West of Asia. To analyze the cases, research team set focus group discussion (FGD) in order to analyze the cases. FGD includes five experts regarding to the different aspects of the issue such as 1- architect (designer), 2- architect (engineer), 3- sociocultural critic, 4- project manager and 5- An expert for life-cycle assessment (LCA) who knows about life-cycle cost (LCC) and life-cycle cost analysis (LCCA).

5. Case studies

5.1. Aspire Tower, Doha
Aspire Tower, also known as The Torch Doha, is a 300-metre-tall (980 ft) skyscraper hotel located in the Aspire Zone complex in Doha, Qatar. Designed by architect Hadi Simaan and AREP and engineer Ove Arup and Partners. The tower served as the focal point for the 15th Asian Games hosted by Qatar in December 2006. [28] Aspire Tower is also known as Al Aziziyah, or Sports City Tower which built to house the Symbolic Flame of the 2006 Asian Games. The design symbolizes a hand grasping the torch that sits at the tower’s top. (Figure 1) [29]

5.2. Financial Harbour, Bahrain
Bahrain Financial Harbour (BFH) is a large-scale commercial development project, mainly completed in 2009, in Manama, the capital of Bahrain. The majority of the project is being constructed on reclaimed land. The two tallest twin-towers (Commercial East and Commercial West) are currently listed as the tallest completed towers in Bahrain, with a height of 260 m. [30] This was raised as an attempt towards new generation of Dubaization in West of Asia. (Figure 2)

5.3. World Trade Center, Bahrain
The Bahrain World Trade Center (also called Bahrain WTC or BWTC) is a 240-metre-high, 50-floor, twin tower complex located in Manama, Bahrain. The towers were built in 2008 by the multi-national architectural firm Atkins. The Bahrain World Trade Center integrates large-scale wind turbines into its design; and together with numerous energy reducing and recovery systems, this development shows an unequivocal commitment to raising global awareness for sustainable design. (Figure 3) [31]

![Figure 1. Aspire Tower, Qatar. [29]](image1.png)
![Figure 2. Bahrain Financial Harbour. [30]](image2.png)
![Figure 3. World Trade Center, Bahrain. [31]](image3.png)
5.4. Chelsea Tower, Dubai
Chelsea Tower is a 250 m skyscraper located on Sheikh Zayed Road in Dubai, United Arab Emirates. The 49 storey building is occupied by a hotel and residential apartments. Chelsea Tower is the 17th-tallest building in Dubai, and one of the tallest residential buildings in the world. When completed in 2005, Chelsea Tower was the fifth tallest building in the city. [32] The building as a monumental statue could easily be seen on Sheikh Zayed Road in Dubai. (Figure 4)

5.5. Jumeirah Emirates Towers
Jumeirah Emirates Hotel Tower, also known as Emirates Tower Two, is a 56-storey hotel in the city of Dubai, United Arab Emirates. The hotel includes 40 luxury suites and is operated by the Jumeirah International Group. At a structural height of 309 m, Emirates Towers Hotel is the smaller of the two sister towers. It ranks as the 48th-tallest building in the world. It is the world's third-tallest all-hotel building. Construction was completed on 15 April 2000. (Figure 5) [33]

5.6. Liberation Tower, Kuwait
Liberation Tower is the symbol of Kuwaiti liberation, the representation of country’s resurgence, second tallest tower in Kuwait, and the fifth tallest telecommunication tower in the world. Officially unveiled by the late Kuwaiti Amir, Sheikh Jaber Al-Ahmad Al-Sabah on 10th March 1996, this 372meter tall tower is 40 meters taller than the Eiffel Tower. The tower is so-named following the multinational coalition that led to liberation of the nation from seven months of Iraqi occupation during the Gulf war. (Figure 6) [34]

5.7. Doha Tower, Qatar
Doha Tower, also known as Burj Doha and previously named as Burj Qatar and Doha High Rise Office Building, is an iconic high rise tower located in West Bay, Doha, Qatar. Doha Tower comprises 46 floors above ground, 3 floors below ground and a total gross floor area of approximately 110,000 m². It has no central core, leaving more internal space available to its occupants. [35] The building inspired from Persian mashrabiya and diagrid (diagonal grid) structure. (Figure 7)

5.8. Kingdom Centre, Riyadh, Saudi Arabia
Kingdom Centre is a 99-storey, 302.3 m skyscraper in Riyadh, Saudi Arabia. It is the third tallest skyscraper in the country after the Abraj Al Bait Towers and the Burj Rafal, and is the world's third tallest building with a hole after the Shanghai World Financial Center and Tuntex Sky Tower. (Figure 8) [36]

5.9. Burj al-Arab Tower, Dubai
The Burj al-Arab is a luxury hotel located in Dubai, United Arab Emirates. It is the third tallest hotel in the world; however, 39% of its total height is made up of non-occupiable space. Burj Al Arab stands on an artificial island 280 m from Jumeirah beach and is connected to the mainland by a private curving bridge. The shape of the structure is designed to mimic the sail of a ship. (Figure 9) [37]
5.10. **Capital Gate Tower, Abu Dhabi**

Capital Gate is a skyscraper in Abu Dhabi adjacent to the Abu Dhabi National Exhibition Centre designed with a striking lean. At 160 m and 35 stories, it is one of the tallest buildings in the city and inclines 18° to the west. The building has a diagrid especially designed to absorb and channel the forces created by wind and seismic loading, as well as the gradient of Capital Gate. (Figure 10) [38]

![Figure 7. Doha Tower, Qatar [35]](image)

![Figure 8. Kingdom Center, Saudi Arabia. [36]](image)

![Figure 9. Burj al-Arab Tower, Dubai [37]](image)

![Figure 10. Capital Gate, Abu Dhabi [38]](image)

6. **Discussion**

The FGD was set in order to analyze ten buildings selected randomly from among recently acclaimed buildings in West of Asia. The results might be seen in table 1.

|   | Technical Performance | Economic | Sustainable | Regional Pre-conditions | Social |
|---|-----------------------|----------|-------------|-------------------------|--------|
| 1 | Aspire Tower          | 2        | 4           | 1                       | 0      | 4      | 2.2   |
| 2 | Financial Harbour     | 1        | 0           | 2                       | 1      | 5      | 1.8   |
| 3 | World trade center    | 4        | 4           | 4                       | 4      | 3      | 3.8   |
| 4 | Chelsea Tower         | 2        | 3           | 0                       | 0      | 2      | 1.4   |
| 5 | Jumeirah Emirates Towers | 1      | 2           | 3                       | 2      | 3      | 2.2   |
| 6 | Liberation Tower      | 1        | 2           | 1                       | 0      | 0      | 0.8   |
| 7 | Doha Tower            | 5        | 5           | 3                       | 2      | 1      | 3.2   |
| 8 | Kingdom Centre        | 3        | 1           | 2                       | 1      | 1      | 1.6   |
| 9 | Burj al-Arab Tower    | 4        | 1           | 4                       | 5      | 2      | 3.2   |
| 10| Capital Gate          | 5        | 3           | 3                       | 3      | 3      | 3.4   |
| **Total**                  | 2.8      | 2.5         | 2.3                     | 1.8    | 2.4    |        |

Quantitative as well as quantitative approach towards the main objectives of the research shows that “Technical Performance” is the only criterion in which the result is over 2.5. It might be concluded that the most essential issues in this test, like “Economic Sustainable”, “Sustainable”, “Regional Pre-conditions” and “Social” are not in satisfactory condition. In other words, the projects could not easily be called smart-eco building even sustainable although they might be seen sustainable individually. The statistical outcomes show that there is not enough evidence to name recently acclaimed architecture of West of Asia as “smart” while there are lots of building information modeling schedules in levels of architecture and planning adopted to enhance the level of energy efficiency in these buildings.
7. Conclusion
Based on research achievements, smart-eco buildings have some parameters to distinguish and introduction as follows: 1- Technical Performance, 2- Economic, 3- Sustainable, 4- Regional Pre-conditions and 5- Social. Therefore, those buildings which have not all of these parameters despite of their particular advantages and disadvantages cannot stay on Smart-eco buildings. Due to the analyzes most of the high rise buildings in west Asia technical performance while their costs of build dramatically are high and are not economic. At the next stage, has been considered to sustainability and regional pre-conditions whereas attention to social item is very slightly; in some ways we can deduct that this item has sacrificed for technics and other aspects.

A comprehensive overview on selected case studies shows upcoming dilemma regarding to sustainability despite the fact that those buildings enjoy latest developed technologies: 1- Imported Materials; meaningful amount of the construction materials imported from other countries which imposed shipping costs and glass-house gas (GHG) emission. 2- Predesigned and Borrowed plans: Some essential architectural plans borrowed from foreign-based consultants and there are lack of meaningful data to make architectural critical decisions. 3- Foreign Workforce: major part of workforce especially in skilled-worker side, invited from among other countries which endanger staff wellbeing more than other criteria. 4- Over-Design: The buildings dissipation in adoption of smart and recombinant materials and high technologies. 5- Over-Energy Consumption: Considering embedded energy for manufacturing the building materials as well as shipping and other related issues shows high level of energy consumption.

Therefore the concept of high-performance architecture and the idea of performative building might be different in developing countries. The research summarized the key issues for optimization of energy consumption in contemporary architecture of developing countries: 1- Integrated Strategies for Energy Efficiency: The building industry is in need of an integrated strategies for optimization of energy consumption developing countries especially based on regional pre-conditions, 2- Contextual Solutions: Concentration on contextual design process, inspiration from context and integration of building and site, 3- Embedded and Initial Energy Assessment: It is essential to consider embedded and initial energy consumption as well as running issues, 4- Staff and Occupancy Wellbeing: high-rise buildings and great-scale redevelopment plans are in need of humanistic approaches towards design and performance, 5- Life-Cycle Monitoring: The buildings should be devoted to eco-friendly strategies in performance period as well.

The results of the paper suggests that it is a necessity to transfer to high-performance architecture concept in order to optimize the level of energy consumption in architecture of developing countries. Although the concept of smart-eco building was an influential step towards sustainability in architectural design process, there is immediate need for some more comprehensive concepts based on other essential issues in contemporary architecture of developing countries such as West of Asia, in order to meet sociocultural sustainability, economic sustainability and environmental sustainability. The results of the research emphasize that it is essential to integrate concept of smart-eco building and the concept of biophilic architecture in order to develop meaningful energy efficient building in contemporary architecture of developing countries.

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