Barriers in Implementing Zero Energy Building Policies in the United Arab Emirates

الحواجز التي تعترض تنفيذ سياسات بناء الطاقة الصفرية في الإمارات العربية المتحدة

by

SYED WAQAS ATHER

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Abstract

It is a well-known fact that human activities over the past few decades have led to the cause of climate change. Building sector is responsible for approximately 28% of the overall carbon emissions. To tackle this, several initiatives such as the Sustainable Development Goals are in place to make cities and human settlement inclusive, safe, resilient, and sustainable. In the building sector, Zero Energy Buildings (ZEB) can have a huge impact by demanding a combination of both energy efficiency measures, and reliance on renewable energy generation. Even though, there are examples of ZEB in the European Union, and the United States of America (USA). United Arab Emirates (UAE) is yet to explore the concept of ZEB in entirety. The aim of this paper is to identify the barriers, and challenges in implementing ZEB policies in the UAE. Economic barriers such as the high upfront construction costs, longer payback periods, and need of sustainable model that consider short-term and long-term goals of ZEB were the main barriers identified through a survey. Also, lack of ZEB codes and standards are also seen as a barrier to implement ZEB policies. Reliance on on-site renewable energy for high-rise residential buildings is seen as a challenge to ZEB. For future legislations pertaining to ZEB in the UAE, the existing codes and standards must coexist with the ZEB codes and standards. Also, the targets set for the ZEB must be coherent with the existing strategies such as the UAE Clean Energy Strategy 2050.

مسؤول البناء قطاع .المناخ تغير قضية إلى أدت الماضية القليلة العقود مدى على البشرية الأنشطة أن المعروف ومن لجعل المستدامة التنمية أهداف مثل مبادرات عدة هناك ، ذلك ولمعالجة .الكربون انبعاثات إجمالي من ٪28 حوالي عن يكون أن الصفرية الطاقة لمباني يمكن ، البناء قطاع وفي .ومستدامة ومرنة ومأمونة شاملة البشرية والمستوطنات المدن الرغم على .المتجددة الطاقة توليد على والاعتماد ، الطاقة كفاءة تدابير من بمجموعة المطالبة خلال من كبير أثر لها ولم .(الأمريكية المتحدة الولايات) الأمريكية المتحدة والولايات ، الأوروبي الاتحاد في ZEB من أمثلة هناك أن من التي والتحديات الحواجز تحديد إلى الورقة هذه وتهدف .برمته الزيب مفهوم بعد المتحدة العربية الإمارات تستكشف أطول ، البناء تكاليف مقدما ارتفاع مثل اقتصادية حواجز .المتحدة العربية الإمارات في زيب سياسات تنفيذ تعترض العوائق كانت زيب من الأهداف الأجل وطويلة الأجل قصيرة تعتبر التي مستدام نموذج إلى بحاجة ، الاسترداد فترات حاجزا أيضا يعتبر ZEB ومعايير قواعد إلى الافتقار أن كما .استقصائية دراسة خلال من تحديدها تم التي الرئيسية تحديا المرتفعة السكنية المباني في الموقع في المتجددة الطاقة على الاعتماد ويعتبر .ZEB سياسات تنفيذ دون يحول تتعايش أن يجب والمعايير القائمة المتحدة العربية الإمارات دولة في زيب المتعلقة التشريعات المستقبل .زيب لشركة والمعايير القواعد زيب مع

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Chapter 1 - Introduction

1.1 Background

It is a well-known fact that human activities over the past few decades have led to the cause of climate change (IPCC, 2014). One of the leading contributors to climate change is the energy consumption that led to the significant rise in Carbon Dioxide (CO_2) emissions. Overall, greenhouse emissions have continued to increase on an annual basis (UNEP, 2017).

Even though, United Nations' Emissions Report has reported that over the past few years there was stability in terms of overall CO_2 emissions from the industry, and energy sectors (UNEP, 2017). But, the significant impact of the building and energy sectors on the environment cannot be ignored. For instance, as per the trends of the year 2017, building sector was responsible for $9.2GtCO_2$ emissions i.e. approximately 28% of overall CO_2 emissions. Within the building sector, emissions due to power generation were the main contributor of CO_2 emissions (International Energy Agency and the United Nations Environment Programme, 2018). Furthermore, in 2017, the construction industry was responsible for $11GtCO_2$ emissions i.e. 39% of overall energy related emissions (International Energy Agency and the United Nations Environment Programme, 2018). The emissions of the construction industry are primarily related to the manufacturing of building materials, and these do not include emissions to transport the material at construction sites. Overall in 2017, energy consumption for building, construction, and transportation sectors were as follows: 30%, 6%, and 28 respectively (IEA, 2018).

Figure 1 compares the 3 leading sectors for energy consumption of the world, and the GCC. Globally, industrial (37%), transportation (29%), and residential (22%) were the leaders of energy consumption on a sector wise comparison. In comparison to the world for the year

2016, the sector wise energy consumption in GCC were as follows: industrial (47%), transportation (34%), residential (10%), commercial (5%), and others (4%) (IEA, 2018).

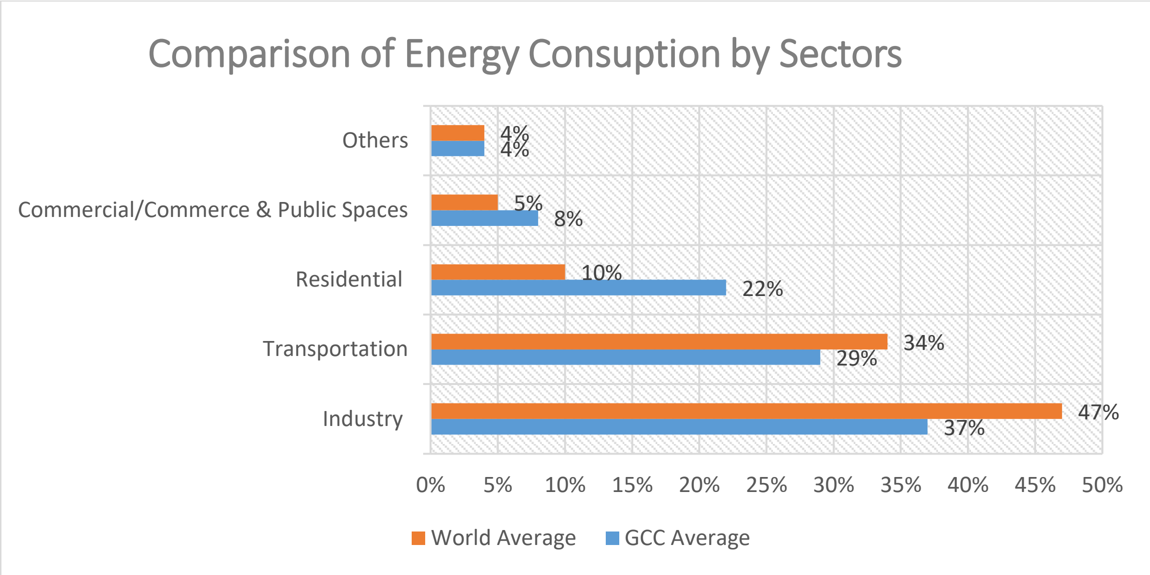

Figure 1: Comparison of Energy Consumption by Sectors (IEA, 2018)

However, in 2017, the CO_2 emissions of the building, construction, and transportation sectors were 28%, 11%, and 23% respectively (IEA, 2018). Within the building sector, residential buildings were found to have high energy consumptions, and CO_2 emissions of approximately 22% and 17% respectively (IEA, 2018).

Moving on from sector wise emissions, to a country wise comparison of CO_2 emissions for the year 2016, it was observed that China, United States, European Union (EU28), India, and Japan were the leading contributors in 2016 (European Union, 2017). However, if CO_2 emissions are compared on a per capita basis, then majority of the Gulf countries led by Qatar followed by Kuwait, United Arab Emirates (UAE), Oman, Bahrain, and Saudi Arabia are in the top 15 for the year 2016 (European Union, 2017).

To minimize the impact of the building sector on the environment, several initiatives were taken, and are being taken to ensure a sustainable built environment. For example, on a global scale, the United Nations has established Sustainable Development Goals to make cities and human settlement inclusive, safe, resilient, and sustainable; and climate action to tackle climate change, and its impact (United Nations, 2015). Firstly, some of the targets for the above-mentioned goals emphasize on the financial and technical assistance to the least developed countries for constructing sustainable and resilient buildings using local materials (United Nations, 2015). Secondly, by 2030, the UN has also asserted to minimize the per capita environmental impact of the cities by focusing on air quality, municipal, and waste management (United Nations, 2015). Lastly, by incorporating climate change measures into national policies, strategies, and planning (United Nations, 2015). On the other hand, another report in 2017also highlighted that to meet the targets of the Paris Agreement i.e. to contain the temperature of the globe within 1.5^{o}C, countries must to increase the renewable energy supply from the current 23.7% to 30% by 2020, halt the approval of any new coal-based fire plants post 2020, and retire the existing coal-based fire plan, and decarbonize buildings by 2050 (UNEP, 2017).

1.2 Problem

On a national level, several initiatives were taken by the construction professionals that promote sustainable living, energy efficiency, air quality, waste management, and renewable energy. For instance, Leadership in Energy and Environmental Design (LEED), BREEAM, DGNB, and Energy Star initiatives were launched to for certifying green building, and energy efficient product. In UAE, in addition to certification of green buildings through LEED green building rating system, Estidama & Al Safat building ratings are in place in the cities of Abu Dhabi & Dubai respectively. In fact, the UAE is at the forefront when it comes to the number of green buildings in the Middle East (USGBC, 2018). The above statistics explicitly imply that current measures are playing a role in curbing the emissions, but certainly more efforts such as the concept of Zero Energy Buildings (ZEB) are needed to tackle emissions and reduce them to an acceptable level.

1.3 Aim

ZEB can play a significant role in minimizing the impact of emissions on the environment, especially in UAE. In the developed countries, policies and frameworks have been established for a transition towards ZEB. On the contrary, the concept of ZEB is not yet fully explored in UAE. Therefore, the purpose of the paper is to identify the barriers in implementing ZEB in the UAE from a legal perspective, challenges confronted by the society to transit towards ZEB, and identify the building sectors where ZEB can be integrated. Therefore, the purpose of the paper is to investigate the feasibility of ZEB in UAE from a legislative perspective. To achieve the aim of the paper, the literature, and countries that have addressed, implemented, and set targets to achieve ZEB will be thoroughly discussed. In addition to this, emphasis will be on the key policies and framework that will accelerate transition towards ZEB. From legislative aspect, the paper will also discuss the mandatory and optional targets for UAE including details for implementation. These targets will coincide with the government goals of achieving energy targets. At last, the paper will discuss the challenges in integrating the concept of ZEB.

1.4 Research Objectives

To achieve the overall aim of the paper, first and foremost objective of the paper is to identify the list of barriers of ZEB discussed in the literature. As ZEB is still a subject of constant research, the list will not confine to geographic locations. Barriers discussed across different locations such as Europe, and USA will be crucial for generating list of barriers. As current definition of ZEB is a combination of RE and EE methods; the discussion of existing policies in the UAE will be crucial for formulating the ZEB strategies. Then, second objective will be the grouping of these barriers in different categories. These categories will assist in indicating the groups, and simultaneously the key barriers that hinder the legislation of ZEB. Third objective is to obtain the feedback of the construction professionals regarding the list of barriers prepared from the literature and identify the main barriers to implement ZEB policies using the mean score. The identification of barriers, and responses will assist the policy-makers, and legislators to focus on areas that are crucial for successful implementation and integration of ZEB practices in the UAE Fourth objective is to discuss the governance strategies ideal for the UAE to adapt ZEB policies. Last objective will be the discussion of several business models that can potentially accelerate toward ZEB policies.

1.5 Research Methodology

First and foremost, the paper will thoroughly discuss, and evaluate the enacted definitions of ZEB in EU, USA, and in the literature. This is primarily to determine inconsistencies in the existing definitions of ZEB. As UAE is the subject of discussion in this paper, there will be discussions regarding the sources of RE ideal for UAE. Then, further discussions for implementing important parameters such as energy efficiency, renewable energy, building sector that are necessary for the ZEB will be addressed and grouped into categories. In this case, for identifying barriers to implementing ZEB in the UAE, the barriers will be grouped in four categories: technical, economic, social, and legislations. These parameters will be identified through literature and countries where ZEB framework and policies is in place. Emphasis will be on the places where temperatures of these places coincide with UAE's temperature. For policy formation, places where ZEB policies are enacted will be discussed from UAE’s aspect. Next, the challenges confronted in the ZEB projects will be reviewed as well.

Then, based on the discussions in the literature, a survey based on the Likert scale will be distributed in the UAE's construction industry for identifying the key barriers in implementing ZEB policies. Post data-collection, the barriers are ranked using the mean score method. From the feedback obtained, the paper will discuss and analyze the barriers from the UAE's perspective. For implementing ZEB policies, the research-based technique is vital for this paper because extensive literature review assists in identifying the barriers across various geographic locations and comparing consistency of barriers in these locations. Another reason for research-based technique is the nature of the paper itself i.e. the legislative parameter pertaining to ZEB is explored where existing and proposed legislative policies are necessary for discussion. Hence, other techniques such as the simulation, or controlled laboratory experiment are not appropriate for this paper.

Chapter 2 – Literature Review

The available literature has focused on several topics such as defining ZEB, establishing common framework for calculation methodologies, pilot projects that focused on the construction methods and materials, and goals and policies defined by the governing bodies across the globe for carbon reductions and ZEB (Bruggmann and Henze, 2018; Wells et. al., 2018; Matthew and Leardini, 2017; AlAjmi et. al., 2016; Krarti and Ihm, 2016; Zhang et. al., 2016; Berry and Davidson, 2015; DOE, 2015; Pan and Ning, 2015; Lindkvist et. al., 2014; Kibert and Fard, 2012; Marszal et. al., 2011). In addition, Pan & Ning (2014) have also discussed about the must needed framework that covers social aspect into consideration for future policy formation, and the challenges confronted by the industry while implementation of ZEB policies. Although the social context is crucial for success incorporation of ZEB concept, social aspects such as occupant comfort, market awareness are often overlooked in the policy formation. In addition to this, the above are mainly discussed from European and North American perspective. There is a dearth of discussion when it comes to ZEB in MENA region. Not to overlook the fact that MENA region is a leading contributor of CO_2 emissions on a per capita basis (European Union, 2017).

Moving on, the definition of ZEBs is keenly discussed in the literature. In fact, over the years, the definition has gone through several revisions, and till date, there is a lack of consensus when it comes to a standard definition that addresses the subject of ZEB in entirety (Marszal et al., 2011; Kibert and Fard, 2012). Kibert and Fard (2012) have discussed the evolution of definitions over the past four decades.

Failure in the lack of standard definitions is primarily due to the differences in the inclusion of life cycle, and embodied energy in the energy balance, renewable energy generation classified as on-site or off-site generation (Marszal et al., 2011; Pan and Ning, 2014). First, as per US Department of Energy's (DOE) definition of ZEB, on-site generation from renewable sources is a must, whereas, as per the Directive on Energy Performance of Buildings of the European Union energy from the renewable resources can either be from on-site or nearby sources (Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings; U.S. Department of Energy, 2015). Second, embodied energy is often disregarded from the calculation due to the added complexities in the results (Pan and Ning, 2014; Hernandez and Kenny, 2010). On the other side, it is often argued that inclusion of embodied energy of materials would comprehensively quantify the actual environment impact of the buildings. Also, keeping the primary focus on the operational phase could affect the overall life cycle impact (Goodchild and Walshaw, 2011; Lutzkendorf et al., 2014). Therefore, the following section will discuss the inconsistency in definitions of ZEB across the globe, and in the legislation section, the policies in place for ZEB across the globe.

Technical aspects included establishing carbon reduction targets, measurements and indicators of emissions, transition towards renewable energy, and ZEB definition and scope. Establishing a common definition of ZEB can be challenging. Concerns regarding ambiguous definitions and its impact on the design target are often highlighted in the literature (Wells et al., 2018; Zeiler and Boxem, 2013). This ambiguity can be accounted for two reasons: different terminology to define ZEB, and various definitions or interpretations of ZEB.

2.1 Inconsistent Definition of ZEB

Over the years, ZEB terminology was often, and is being taken for granted. In the literature, ZEB was often referred to as net-zero energy buildings, nearly zero energy buildings, zero carbon, near net-zero energy homes, and net-zero exergy buildings, and net zero energy cost (Wells et al., 2018; Thomas and Duffy, 2013). In fact, DOE have acknowledged that terms such as Net Zero Energy, and Zero Net Energy are widely used terms, although these terms have the same meaning as Zero Energy (U.S. Department of Energy, 2015). It leads to further confusion amongst consumers, and society when off-grid, and on-grid definitions are discussed. Off-grid & on-grid are associated with the renewable energy requirements of ZEB buildings, which is a must as per the definitions of United States Department of Energy, and Energy Performance of Buildings Directive (Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings; U.S. Department of Energy, 2015). In USA, prior to a consensus on the definition of ZEB, there were several definitions of ZEB (U.S. Department of Energy, 2015; Torcellini et al., 2006). These were either from an emission, energy consumption, or energy costs' perspective. Several definitions were net zero site energy, net zero source energy, net zero energy costs, and net zero energy emissions (Torcellini et al., 2006). Later, in 2015, DOE had introduced the terminology zero energy building for net zero energy buildings (U.S. Department of Energy, 2015). Regarding the net-zero energy buildings (Net ZEB), Sartori et al. (2012) stated that the term 'net' is related to the connection of the buildings with the grid (energy infrastructure) i.e. a balance is achieved between the energy taken from the grid and supplied back to the grid over a certain period. Whereas, ZEB is a more generic term, and it simply implies that the buildings that are autonomous (Sartori, Napolitano and Voss, 2012)

Another concern regarding the ZEB is the availability of various definitions in the literature. One set of definitions comes from the governing authorities across the globe, whereas, the other set of definitions comes from the literary society. In literature, a net-zero energy building is defined as “energy efficient building that generates sufficient energy on-site over the course of a year to supply all expected on-site energy services for the building user” (Berry and Davidson, 2015). Another paper simply defines netZEB as a building that is neutral over a year (Aelenei and Goncalves, 2014). The authors explained netZEB as a building where supplied energy to the grid is equivalent to the energy used from the grid (Aelenei and Goncalves, 2014). Other definitions include netZEB as a very low energy consumption building that is balanced using renewable energy on-site (Garde et al., 2014). At last, Thomas and Duffy (2013) have explained near net-zero energy buildings as homes built to reduce net-energy including an on-site renewable energy to meet energy requirements, however, this renewable energy source does not meet the entire energy requirements of the building. The authors have referred to such homes as super-efficient (Thomas and Duffy, 2013).

For instance, in literature, there are ongoing discussions regarding the inclusion of the embodied energy in the definition of the ZEB, and life cycle analysis. Several authors have discussed the importance of including the energy used to produce materials, and the role it plays in the over the life cycle of the building (Lutzkendorf et al., 2014). Hernandez and Kenny (2010) have highlighted that inclusion of the embodied energy of the building materials, construction and demolition depicts a true environmental impact of the building. Hence, considering only the operating costs of the building would be a misrepresentation of total life cycle impact (Goodchild and Walshaw, 2011; Lutzkendorf et al., 2014). However, it was also argued that embodied energy and transportations calculations are subjected to complex and inconsequential results (Pan and Ning, 2014). But the importance of including the embodied energy i.e. energy to produce the material and deliver the material at site can be seen from the fact that transportation sector is primarily responsible for approximately

29% of energy consumption in USA where the majority of transportation sector uses petroleum as a source (U.S. Energy Information Administration, 2018). For 2016, in USA, the transportation and the residential sectors were responsible for approximately 38% of energy consumption (U.S. Energy Information Administration, 2017). From these statistics, it is well understood that transportation sector is not responsible for embodied energy in entirety, but the use of vehicles to transport goods cannot be ignored in the life-cycle analysis. Based on the above statistics and discussions in the literature, it is evident that the construction industry and the governing authorities are yet to reach a consensus when it comes to inclusion of embodied energy in the life cycle analysis, and definition of ZEB even though statistics clearly state otherwise.

Several aspects of ZEB such as lifecycle cost analysis, energy efficiency, passive design, consistent definition, were discussed in the literature. To group these discussions, there are four key parameters of ZEB i.e. technical, social, economic, and regulatory. All these must work in tandem to ensure established targets are achieved, and this is applicable for any country. The following Diagram 1 illustrates the relation of ZEB and the four key aspects necessary for policies of ZEB. This paper will briefly discuss the technical, social, and economic aspects, and most of the discussion will be around the legislative aspect.

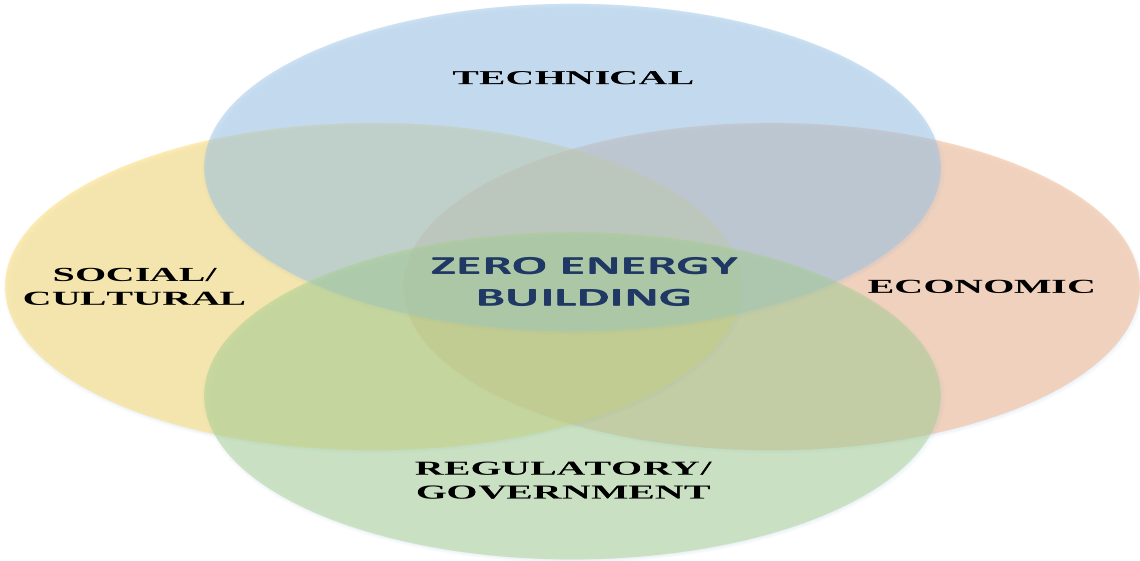

Diagram 1: Parameters of ZEB

2.2 – Technical Aspect of ZEB

In an earlier study by NREL, it was evaluated that a single-story office building has a likelihood of achieving ZEB performance, whereas, a two story can struggle to achieve ZEB performance (National Renewable Energy Laboratory, 2006). Moving on, for considering PV as a source of RE, location of the building, energy footprint of the building, and the efficiency of the PV technology effect the number of floors in the building are crucial factors to the design of ZEB (Kibert, 2012). The following sections will discuss the Global Horizontal Irradiation, and Direct Normal Irradiation of the Middle East, and the reasons of PV being the ideal option as a RE source for ZEB in the UAE.

As the main purpose of the paper is identification of the barriers in the UAE, this paper will briefly discuss the technical aspects discussed in the literature. Predominantly, several prescriptive studies have analyzed the technical features, and their application on the ZEB. These measures include building shapes, orientation, size and location of the windows, glazing details, insulation of exterior and interior walls, lighting fixtures, temperature, energy efficiency of HVAC systems, and the use of PVs (Bruggmann and Henze, 2018;

AlAjmi et. al., 2016; Krarti and Ihm, 2016). The simulation results have shown that ZEB buildings are certainly an option worth exploring. For instance, retrofitting public buildings with energy efficiency measures, and installing PVs on the roofs can yield positive results (AlAjmi et. al., 2016). Similarly, optimizing residential buildings can lead fruitful results (Krarti and Ihm, 2016). Krarti & Ihm found out that the technical considerations, use of PVs for renewable energy generation, and with the use of energy efficient appliances, the buildings in the MENA region can achieve the ZEB status. Other simulations were inclined favoring the zero-energy status (Matthew and Leardini, 2017). There are also performance-based evaluations of ZEB as well (Thomas and Duffy, 2013; Iqbal, 2004). For example, in New England, a relatively colder region in the USA showed that houses can achieve the status of ZEB. Thomas and Duffy (2013) compared the predicted, and measure energy consumption of homes in New England, USA, and it was found out that met or exceeded the designed energy performance (Thomas and Duffy, 2013). On the other hand, Zeiler and Boxem (2013) found out that the indoor air quality of ZEB school in Netherlands was below average in comparison to traditional schools. Zeiler and Boxem asserted the need to change in design approach for achieving ZEB (Zeiler and Boxem, 2013).

In addition to these, grid stability, and the importance of two-way grids are also discussed in the literature (Bruggmann and Henze, 2018; Sartori et. al., 2012). Even though, ZEB tend to bring the energy consumption to a minimum by generating on-site energy through renewable resources. With the high residual loads (simply the difference between the electricity demand, and the on-site electricity generation) of ZEBs, grid operators have little incentive in stabilizing grid, and this entails a risk on the grid (Bruggmann and Henze, 2018). Battery storage systems are crucial in minimizing the impact of residual loads on the grid (Bruggmann and Henze, 2018). On the other hand, Sartori et. al. has asserted in the absence of two-way grid, the chances of fulfilling ZEB requirements are minimum. So, the role of grid operators in accepting exported energy is crucial (Sartori et. al., 2012).

In the earlier sections, inconsistencies in definition of ZEB were already discussed. Now, the concept & potential of renewable energy will be discussed from a global perspective, and then from UAE's perspective.

2.2.1 Renewable Energy (RE)

As per EIA, RE is simply energy from sources that replenish naturally but are available at a certain period i.e. time dependent (2018). For instance, solar energy can be advantageous at daytime, or wind energy can only be utilized when there is certain threshold of wind. EIA's includes but is not limited to the following: solar, wind, geothermal, and hydropower (2018). Kibert & Fard (2012) have argued that one of the reasons for inconsistent definition of ZEB is the lack of unified definition of RE. However, definitions of RE do not differ to that extent. For instance, as per the Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, RE is defined as "energy from non-fossil sources such as wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, and biogas". Whereas, in USA, Energy Policy Act of 2005 describes RE as electricity generated from wind, solar, biomass, landfill gas, ocean, geothermal, municipal solid waste, and hydroelectric generation. Moving on, the definitions of RE are consistent across the globe. In fact, the several ZEB definitions discussed in the literature have considered RE an integral part of ZEB. But, the availability of site, and enough roof area for generating renewable energy preferably from PVs is one of the challenges, and a vital aspect of achieving ZEB (Kibert, 2012). Second, battery storage systems are not cost-effective for now (Bruggmann and Henze, 2018). These scenarios tend to hamper the drive towards ZEB. Third, disagreements arise over the on-site or off-site RE requirements of ZEB. Last, to meet common objectives of Paris Agreement, unified definitions are of utmost importance for two reasons: for smooth transition towards energy efficient practices, and most importantly, check & balance of these practices. Presently, the battery systems are not cost effective, but, as time progresses, the technological improvements in the battery storage systems and PVs will certainly drive the demand of ZEB.

2.2.2 Prospects of RE for ZEB in UAE

The GCC region that includes countries such as UAE, Saudi Arabia, Oman, Kuwait, Bahrain, and Qatar has exceptional potential of solar energy especially photovoltaic resources (PV) (IRENA, 2019). In fact, Saudi Arabia, Oman, and Kuwait have additional potential of wind resources (IRENA, 2019). With UAE being the focus for policy making, the discussion will be on the solar energy only. The average Global Horizontal Irradiance (GHI) of UAE is 2200 kWh/m^2/year makes UAE an ideal location for solar PV resources (World Bank Group, 2017a). In fact, UAE was able to draw attention to low-cost PV projects without subsidies (Apostoleris et al., 2018). Figure 2 illustrates the daily, and yearly GHI readings for the Middle East region.

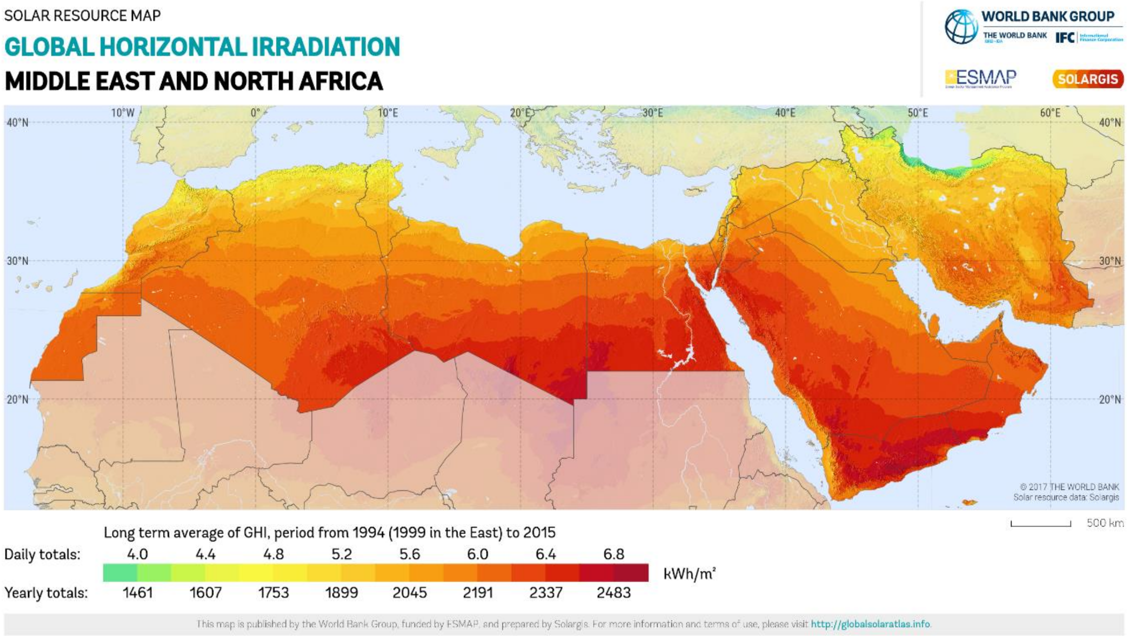

Figure 2: World Bank Data on GHI Readings in the Middle East (World Bank Group, 2017a)

In addition to this, even though Saudi Arabia and Oman have the ideal Direct Normal Irradiance (DNI) readings for concentrated solar power (CSP) technologies in the GCC region (IRENA, 2019). Lack of ideal conditions did not deter UAE to pursue CSP projects. Recently, UAE managed to complete the 700MW CSP related project (IRENA, 2019). Completion of such projects highlight two factors: low costs of solar energy projects, and authority’s intention to transit towards renewable energy. The following Figure 3 depicts the countries with high DNI readings particularly Northwest region of Saudi Arabia, and Northeast & Southwest region of Oman (World Bank Group, 2017b).

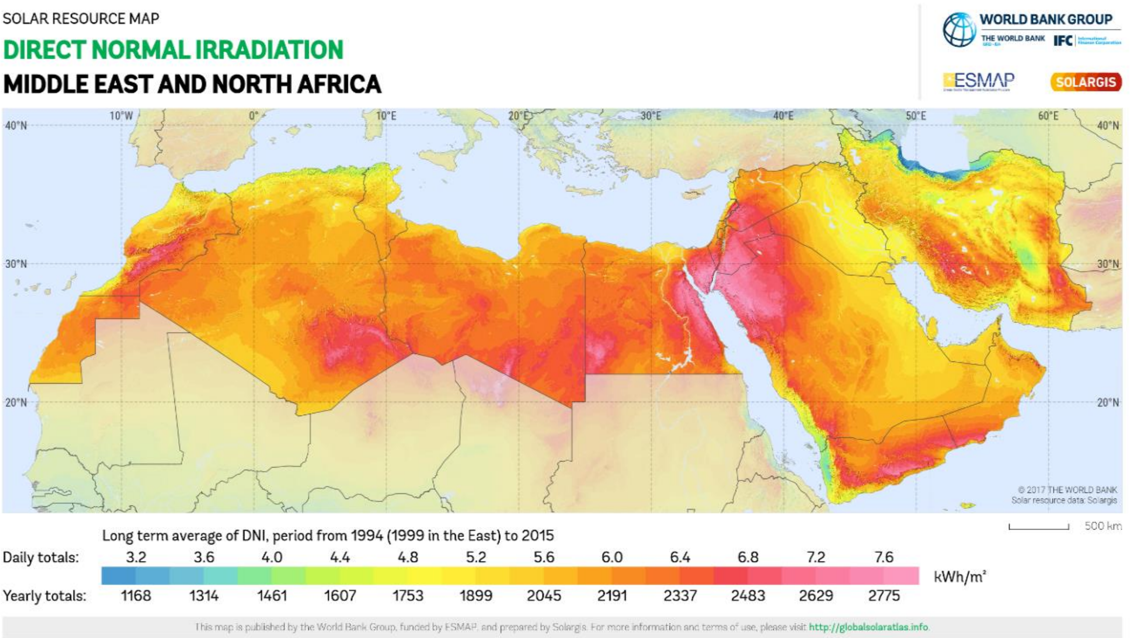

Figure 3: World Bank Data on DNI Readings in the Middle East (World Bank Group, 2017b)

As of 2017, majority of the electricity was generated by the natural gas, followed by oil products, and crude oil respectively (IEA, 2018; IRENA, 2018). Whereas, globally, energy production from coal was approximately 38.2%, oil and natural gas contribution to energy production was 3% and 11 % respectively. Altogether, oil and natural gas were the least contributors in the energy generation mix (IEA, 2018). Figure 4 compares the energy mix of the world and the GCC region.

Comparing this with renewable energy sector, keeping UAE aside, the GCC countries had an overall contribution of less than 1% to generate electricity from the renewable sources in 2016 (IEA, 2018; IRENA, 2018). Whereas in 2016, overall power generation from renewables i.e. hydro being at the forefront of renewables followed by solar, and wind across the globe is 24.2% (IEA, 2018). Overall, on an international scale, power generation from renewables is ranked second in energy generation mix (IEA, 2018).

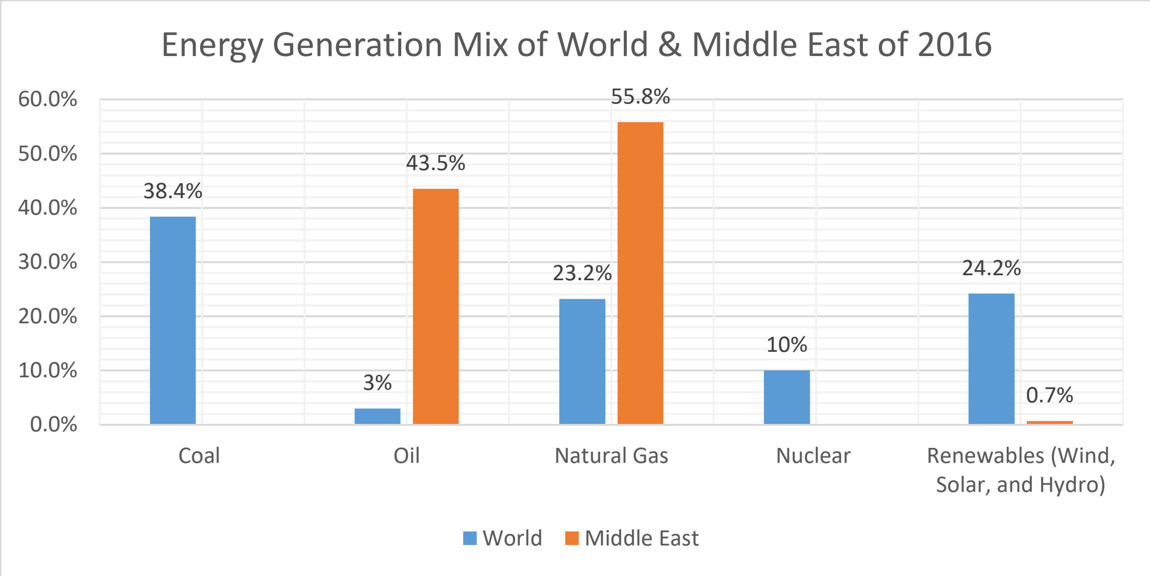

Figure 4: Energy Generation of Mix of World & Middle East (IEA, 2018)

Based on the above discussions, it is seen that there is immense potential of RE in the UAE as well in the neighboring countries. However, currently, the contribution of RE towards energy generation is not significant, and certainly, increasing the percentage of RE in the energy mix can have significant contributions towards achieving UAE's energy targets, compliance to Paris Agreement, and encouraging ZEB. RE's policies and targets of the regions will be discussed in the later sections. On the other end, there is a massive drive towards incorporating RE in the energy mix as the GCC tends to add 6.7GW in the power generation capacity in the first half of 2020 (IRENA, 2018). Majority of these additions will be through PV projects followed by CSP, and wind projects (IRENA, 2018). In fact, over the past two years 2017-2018, GCC have added 867MW to the energy generation capacity by RE (IRENA, 2018). Moreover, Saudi Arabia intends to increase the renewable energy share to 3.45 GW, and 9.5 GW for the years 2020, and 2023 respectively. For the year 2023, the targets were revised to 27.3GW (Renewable Energy Project Development Office, 2019a). In addition to this, by 2030, Saudi Arabia has intentions of increasing the share of renewables to 58.7 GW i.e. solar (40%), wind (16%), and CSP (2.7%) (Renewable Energy Project Development Office, 2019a). Keeping the discussion of onsite and off-site

RE aside, literature unanimously agrees on the inclusion of RE in ZEB definition. On the contrary, countries are yet to tap the potential of RE, and only by utilizing these resources, the society can reap the benefits of ZEB in whole.

2.2.3 Energy Efficiency

Over the past few decades, there was a significant rise in the demand of electricity in the GCC region. In actual, since 1990, there is a fourfold increase in the energy demand (IRENA, 2019). The rise in energy demand was due to several factors: economic growth, industrial expansion, growing populations, high incomes, and high living standards (IRENA, 2019). Furthermore, due to limited energy efficiency regulations, and low costs of petrol, electricity and water have often given little incentives to conserve resources or use resources efficiently. (UN ESCWA, 2017, Chatam House, 2013). Due to these reasons, renewable energy along with low costs of installation, and energy efficiency techniques have gained massive attention to respond to rise in energy demand (IRENA, 2019). Not to overlook the fact that residential sector is responsible for 50% of the electricity consumed in the GCC (IEA, 2018). This is primarily due to the demand of air conditioning in extreme hot conditions especially during midday, and evenings (IRENA, 2019). With limitations of on-site energy generation and the affordability of battery storage systems, the literature identifies energy efficiency as a key component of achieving ZEB status (Bruggmann and Henze, 2018; Thomas and Duffy, 2013; Sartori et. al., 2012). But, energy efficiency measures such as selection of appliances, insulation, air tightness, HVAC systems, windows, and renewable resource, and solar water heaters have led to positive results for achieving ZEB status (D'Agostino and Parker, 2018).

2.2.4 Technical Barriers of ZEB

On reviewing the literature, there are several barriers that hinder the goals of achieving the ZEB status. First and foremost, inconsistent definition across the western part of the globe is seen as a barrier (Zhang et. al., 2016; DOE, 2015; Kibert and Fard, 2012; Sartori et. al., 2012; Marszal et. al., 2011). Different definitions tend to confuse the society in terms of achieving certain objectives. For instance, EU is aligned towards achieving nearly ZEB status, whereas, in USA, several states have adopted several ZEB definitions as seen in the case of California, Cambridge, Oregon, Arizona, and New York. The paper will shed light on the definitions of ZEB in the legislative section.

Second, lack of technical understanding of ZEB concepts, and previous experiences in the field of ZEB is also seen as a barrier in the literature (Zhang et. al., 2016; Linkvist et. al., 2014; Pan and Ning, 2014; Sartori et. al., 2012; Marszal et. al., 2011). Most of the projects discussed in the literature are either pilot projects, or newly constructed. Third, several definitions are available to capitalize on the concept of ZEB. For example, either in legislative, or in literature ZEB is defined in terms of costs, emissions, on-site & off-site renewable energy generation, and consideration of embodied energy in the life-cycle calculations (Zeiler and Boxem, 2013; Kibert, 2012; Marszal et. al., 2011; Hernandez & Kenny, 2010; Iqbal, 2004).

Fourth, establishing realistic energy consumption targets are a concern for ZEB as well. In Sweden, high energy consumption as a baseline was a barrier as it is against the principle of ZEB i.e. minimizing energy consumption (Linkvist et. al., 2014). Fifth, difference in performance of ZEB is seen as well. Basically, in colder regions, the predictive, and measured performances were inconsistent (Thomas and Duffy, 2013). Sixth, literature has highlighted the success of ZEB being limited to either single-story buildings or not exceeding multi-story buildings (Kibert and Fard, 2012). This is because of the need of substantial site area to generate enough renewable energy, which is another barrier (Kibert and Fard, 2012; Sartori et. al., 2012). Last, literature has highlighted the impact of feeding electricity into the gird, and its impact on the stability of the grid (Bruggmann, and Henze, 2018). The grid stability becomes an issue because of the variance in the peak loads between an annual period (Bruggmann, and Henze, 2018).

2.3 – Social Aspect of ZEB

Even though there is significant literature highlighting the relation of energy consumption with the efficiency of appliances and HVAC systems, and design factors. Discussions regarding the behavior of the humans in relation to the consumption are missing. In a study of Energy Star and non-Energy Star homes in Nevada, USA, Shrestha and Kulkarni determined the correlation between the building characteristics and the homeowners' behavior with the energy consumption of residential buildings (Shrestha and Kulkarni, 2013). Shrestha and Kulkarni found out that irrespective of using energy labeled (Energy Star) equipment and appliances, characteristics of the appliances and the frequency of using these appliances were positively correlated with the energy consumption of the residential building. In fact, the choices, and comfort zone of the homeowners were related with the energy consumption of the buildings. In addition to this, the study showed that age, and frequency of using the equipment i.e. air conditioners, and appliances such dishwashers, and washing machines were correlated with the energy consumption. The above observation demonstrated that efficiencies play a vital role in conserving energy (Shrestha and Kulkarni, 2013), and homeowners should focus on upgrading the systems of the homes on a regular basis (Shrestha and Kulkarni, 2013). On the other hand, some studies have shown that Energy Star certified residential buildings consume 15-30% less energy compared to an average new residential building. Moving on, in a comparison of LEED and non-LEED certified, there is no significant difference in satisfaction levels of indoor environmental quality (Schiavon and Altomonte, 2014).

The idea of upgrading the systems, and appliances leads to the concern of costs associated with these upgrades that are discussed above. But, to highlight, the above study has shown that the frequency of use does have a role in raising the energy consumption. Hence, the focus should on minimizing the frequency of use which is a concern related with the behavior of the humans. These concerns of occupants' behavior to reduce overall energy use by practicing energy efficient techniques are discussed by several authors as well (Kibert, 2012; Peschiera, et. al., 2010). Shrestha and Kulkarni have also suggested that homeowners can compromise on the level of comfort to reduce the energy consumption (Shrestha and Kulkarni, 2013). Kibert proposed the use of interactive control and feedback systems designed assist occupants in making well-informed decisions that as a result reduce energy consumption (Kibert, 2012).

In another study, social factors such as the health, indoor air quality, thermal comfort, personal productivity, visual comfort, environmental protection, and energy cost savings were evaluated from a level of importance and satisfaction in the USA across three states namely Arizona, Illinois, and Pennsylvania (Amasyali and El-Gohary, 2016). The levels were determined by seeking responses of occupants in the residential, and office buildings. In terms of importance, the above factors were considered as at least moderately important in both residential and office buildings. However, differences were seen for the energy cost savings. The residential sector was more concerned for the energy cost saving, whereas, this was not important in the office buildings. In the office buildings, visual comfort, and productivity were given far more importance. For the satisfaction, the feedback was unanimous, but there were disagreements over the thermal comfort. Occupants of the residential buildings were more satisfied with the thermal comfort than the occupants of the office buildings. Based on the above, the authors highlighted the need to find innovative approach to improve the energy use behavior of the occupants in the office buildings (Amasyali and El-Gohary, 2016).

2.3.1 Social or Cultural Barriers

Some studies have also discussed social barriers that stagnate the implementation of ZEB. For instance, there was deficiency in disseminating knowledge among stakeholders (Lindkvist et. al., 2014; Pan and Ning, 2014). Stakeholders can be project participants, decision-makers, and the society. Similarly, lack of participation, and engagement of project participants was also seen a barrier (Zhang et. al., 2016). Lack of participation and engagement can be due to several factors such as previous experiences in ZEB, negligible technical knowledge, and lack of intent to transit towards ZEB concept. Another barrier is the awareness regarding the concept of ZEB (Pan & Ning, 2014). As ZEB is a concept not explored in entirety, society is not acquainted with the ZEB concepts. With the passage of time, when significant literature and case studies are available to showcase the positive impact of ZEB. As a result, there will be an increase in awareness of ZEB concepts. Like awareness, lack of education and training regarding the ZEB is also seen a barrier to implement ZEB (Zhang et. al., 2016). This is associated with the codes and regulations in place in a specific region. As seen in the case of California where ZEB codes are in place, emphasis is on the creating awareness, increasing participation, and improve the quality of education to professionals regarding ZEB for encouraging ZEB homes. Next, in countries like Norway and Sweden, it is seen that architectural, and cultural values of a building contain the true potential of ZEB (Lindkvist et. al., 2014; Kibert and Fard, 2012; Marszal et. al., 2011). Mostly, there are several places across the globe where history plays a significant role to define the values, and most importantly, as a mean of driving tourism in a country. In these locations, cultural values can potentially hinder the role of ZEB. Moving on, in occupying a ZEB, environmental and health indicators of a building can potentially impact the buildings (Lindkvist et. al., 2014; Berry & Davidson, 2015). On evaluating a ZEB in Netherlands, it was seen that there is no significant improvement in the indoor air quality (Berry & Davidson, 2015). As time progresses, and people push for ZEB, the environmental and health concerns will not be a concern eventually. Lastly and most importantly, changing the occupant behavior to minimize the energy consumption will be a daunting task (Pan and Ning 2014; Thomas and Duffy, 2013; Kibert, 2012). In extreme climatic conditions, efficient HVAC systems will be crucial, as temperature rises or drops drastically, the need to provide ambient cooling and heating increases respectively. But, as highlighted by Shrestha and Kulkarni (2013), the efficiency of the equipment is a direct correlation with the age of the equipment.

2.4 Economic Aspect of ZEB

2.4.1 Investment in Clean Energy

This section discusses the type of investment strategies in place that are focusing on the clean energy, and renewable energy. In the UAE, the expected investment through the UAE Energy Strategy 2050 is expected to be approximately AED 600B (Ministry of Energy & Industry, 2017). In Saudi Arabia, until 2023, the government tends to attract an investment between AED 30B-50B for renewable energy projects. As per the Energy Policy Act 2005, USA is also keen to push for incentives of RE.

2.4.2 Financial Incentives in the Energy Sector

In Europe, especially Germany, Spain, France, Italy, United Kingdom, Belgium, and Greece, several economic policies were adopted for public awareness, and increase in renewable energy share in the market (Ramírez et al., 2017). In fact, these seven countries were at the forefront on leading PV development in the European region. These seven countries were responsible for 85.7% of the total installed PV in the European region (Ramírez et al., 2017). Several policies encouraging RE sector were promoted in these countries. These economic policies include investment subsidies, tax reductions, soft loans, Feed in Tariffs (FiT), and Renewable Energy Certificates or Green Certificates. First, investment subsidies are awarded based on the percentage of renewable energy output, and upfront investment cost (Ramírez et al., 2017). Second, tax reductions are primarily tax exemptions, or lower tax rates on renewable energy (Ramírez et al., 2017). Third, soft loans are basically provided the local authorities at a rate lower than the market interest rates (Ramírez et al., 2017). Fourth, in the FiT, the producer of renewable energy receives a fixed rate per kWh generated electricity. The rates are set by the government (Ramírez et al., 2017). The above economic incentives, and policies under Renewable Energy Directives have convinced the European market to shift towards renewable energy. These policies were also the reason that European Union was able to meet its renewable energy targets of 2020 well in advance.

Similarly, Department of Energy had also introduced SunShot initiative with the aim of reducing the cost of PVs by 75% by 2020. By achieving this target, PVs will become more competitive on a large-scale without the need of subsidies. In 2017, the goal was achieved i.e. $0.06/kWh, and the goal was revised to $0.03/kWh. As per the revised goal in the SunShot 2030, the PVs will be more cost effective, and least expensive for power generation when compared with fossil fuels (NREL, 2017). Cost incentives initiative such as SunShot encourage the society to imbibe RE programs, and adopt programs that are sustainable from a cost, and environment's perspective. Besides this, the tax policies on renewable energy also ensured that early adopters of the RE programs are awarded the benefits of transitioning towards clean energy. Several tax credit policies such as Production Tax Credit, Investment Tax Credit, and Modified Accelerated Recovery System Depreciation Schedule, and Department of Energy's Loan programs have lured the consumers to reconsider current practices of energy consumption. Investment Tax Credit purpose is to offset the upfront costs by 10-30% energy (Zhou, 2015). Whereas, Production Tax Credit is simply a tax credit for per kWh generated from renewable resources, and sold by the taxpayer (Zhou, 2015). Even though, these fall under the category of policymaking, but, due to economic incentives, these are placed under the category of economic parameter.

In the UAE, the surge in installation of PVs was primarily for imbibing a slightly different approach i.e. Call for Tenders. As discussed in the earlier section, UAE is driving the growth of renewable energy in the GCC region. One of the reasons is the Call for Tenders approach. In this approach, the government invites the renewable energy generators for meeting financial budget, or meeting the capacity target (Ramírez et al., 2017). Another policy in practice in the UAE is the net metering program called Shams Solar Program. In this program, homeowners can install PVs at rooftops, and feed excess electricity into the grid.

2.4.3 Life Cycle Definition & Embodied energy

For ZEB, there are several discussions regarding the inclusions of embodied energy in the calculations besides the operational aspects. Hernandez and Kenny's definition of embodied energy is often cited, and discussed in the literature (Hernandez and Kenny, 2010). Majority of the definitions enacted in different places have primarily focused on the operational elements of the building. Hernandez and Kenny have argued that embodied energy must be accounted as well. Hernandez defines ZEB as a life cycle zero energy building (LC-ZEB). Where LC-ZEB is a building whose primary energy use during the operations including the embodied energy of materials and systems over the course of their life is less than or equal to the energy produced by renewable energy of the building (Hernandez and Kenny, 2010). There are several other authors who endorse this definition (Marszal et al., 2011; Pan and Ning, 2014).

2.4.4 Economic Feasibility of ZEB

Currently, the economic impact of ZEB is discussed in two aspects i.e. retrofit, and new construction. Literature has highlighted the investment cost to pursue ZEB buildings can vary between $8300- $15,166 (Anderson et. al., 2006). This is dependent on the location. For instance, in places like Belgium the costs can escalate up to €37,000 (Audenaert et. al., 2008). For this reason, Leckner and Zmeureanu have emphasized on the need of affordable technology (Leckner and Zmeureanu, 2011). But again, even though ZEB have higher upfront costs if compared with regular houses, Marszal et. al. has argued that overall costs of ZEB are lower because of lower energy use, and on-site renewable energy generation (Marszal et. al., 2011).

On the other hand, there are discussions in the literature that highlight the cost-effective design measures for achieving ZEB status in the EU region (D'Agostino and Parker, 2018). D'Agostino and Parker found out that buildings can achieve ZEB status with minimum costs across various cities in the EU (D'Agostino and Parker, 2018). Similarly, in Canada, the results were on the positive side as well (Asaee et. al., 2019). Through careful selection of retrofit options, a major share of the Canadian housing stock can achieve ZEB status by curbing energy consumption and reducing greenhouse gas emissions. Retrofit options include envelope modifications, appliance/lighting upgrades, and phase change materials (Asaee et. al., 2019). Furthermore, Asaee et. al have stated that ZEB models can support in achieving two of the four actions under Pan-Canadian Framework on Clean Growth and Climate Change demand construction of energy efficient buildings, and retrofit existing buildings, (Asaee et. al, 2019). In terms of cost to retrofit buildings in Canada, Asaee et. al. estimated costs of approximately C$ 23,637, and C$18,319 (Asaee et. al., 2019). These are on the higher end if compared with the invest costs highlighted by Anderson et. al. (Anderson et. al., 2006).

2.4.5 Economic Group of Barriers

To say most the of the literature focused on the economic group of barriers would not be wrong. First, high energy subsidies have a debilitating effect on the cost-effectiveness of ZEB (Krarti and Ihm, 2016; Berry & Davidson, 2015; Leckner and Zmeureanu, 2011; Audenaert et. al., 2008). For instance, a model to evaluate the possibility of achieving zero energy status in the MENA yielded positive results. However, accounting for energy subsidies showed that ZEB are not that cost effective (Krarti and Ihm, 2016). Second, lack of financial incentives to pursue ZEB is also seen as a barrier as seen in the case of Europe (Wells et. al., 2018; Matthew and Leardini, 2017; Lindkvist et. al., 2014). To tackle this issue, California ZEB action plan is keen on providing financial incentives for ZEB. Third, literature has highlighted the longer payback periods as a concern for implementing ZEB (Wells et. al., 2018; Lindkvist et. al., 2014; Carrilho de Graca et. al., 2012; Leckner and Zmeureanu, 2011; Audenaert et. al., 2008; Anderson et. al., 2006). For instance, several studies in Australia, Kuwait, and Portugal have found that overall payback period for ZEB ranges between 7-23 years (AlAjmi et. al., 2016; Boemi et. al., 2015; Carrilho de Graca et. al., 2012). Fourth, another concern is the high upfront investment costs associated with the ZEB whether it is new construction, or a retrofit project (Wells et. al., 2018; Matthew and Leardini, 2017; Berry & Davidson, 2015; Linkvist et. al., 2014; Zeiler and Boxem, 2013; Carrilho da Graca et. al., 2012; Leckner and Zmeureanu, 2011; Marszal et. al., 2011; Audenaert et. al., 2008; Anderson et. al, 2006). These high costs are seen in different parts of the region such as the Australia, and the Europe. Fifth barrier is the lack of business models that consider both long-term, and short-term goals of ZEB (Wells, et. al., 2018; Berry and Davidson, 2015; Linkvist et. al., 2014; Osterwalder and Pigneur, 2013). There is little discussed in this regard, and most of the discussions in the literature are pertaining to lice-cycled of ZEB. Sixth, with on-site renewable energy generation in a ZEB, surplus electricity is feed into the gird. This often destabilizes the grid, and the grid operators need to act by maintaining the grid (Bruggmann, and Henze, 2018). On the contrary, there are no financial incentives for the grid operators to maintain the grid (Bruggmann, and Henze, 2018). Seventh, there are no short-term goals for ZEB, there is an emphasis on considering a long-term goal of lowering the overall maintenance costs (DOE, 2015). The need to focus on a long-term goal can deter both the decision-makers in implementing and pursuing ZEB projects. In fact, this has a risk of decision-makers considering economic impacts instead of implementing energy efficiency goals (Matthew and Leardini, 2017; Linkvist et. al., 2014).

Lastly, in Europe, where this is mix share of homeowners and tenants, there is a concern of loss of revenue for retrofitting a project (Linkvist et. al., 2014). Basically, from a homeowner's perspective, the tenants are asked to vacate a building while retrofit works are underway. However, this may not be a concern for a new construction.

2.5 Legislative Aspect of ZEB

2.5.1 Introduction

This section discusses the governance model and strategies of cities promoting and practicing ZEB. The government policies are key drivers of RE market especially the PV market; energy share and economic incentives have had an exceptional impact worldwide (Comello and Reichelstein, 2017; Jordan, 2014). In addition to this, further discussions will be on the policies of RE, energy efficiency, and ZEB across the globe with GCC, EU, and USA will be the primary countries of discussion. To say, there is a significant rise in the use of RE would not be wrong. By the end of 2017, 179 countries had renewable energy targets, several jurisdictions have adopted feed-in-tariffs, and renewable portfolio standards for RE (REN21, 2018).

Besides technical, social, economic aspects, policy aspect forms an integral part of ZEB. These policies could be affiliated to RE, energy efficiency, and ZEB itself.

2.5.2 Policies of RE in GCC

UAE has enacted UAE Energy Strategy 2050 with the intention of increasing the share of clean energy to 50% i.e. 44% for clean resources, and 6% for nuclear (Ministry of Energy and Industry, 2017). On an emirates level, Dubai has enacted several clean energy policies that include Dubai Clean Energy Strategy 2050, and DIES 2030 (Dubai Electricity and Water Authority, 2017; Dubai Supreme Council of Energy, 2017). Moving onto Saudi Arabia, the government of Saudi Arabia had formed the Renewable Energy Project

Development Office (REPDO) to meet the National Renewable Energy Program's targets under the umbrella of Vision 2030 (Renewable Energy Project Development Office, 2019a). Over the upcoming years, REPDO will work in synergy with numerous energy authorities to deliver the NREP goals (REPDO, 2019b). The goal of NREP is to increase the share of RE to meet energy demands of Saudi Arabia (REPDO, 2019b). Besides Saudi Arabia & UAE, Kuwait, Oman, and Qatar are yet to enact renewable energy policies although there are examples of pilot projects, and initiatives within the renewable energy sector. For instance, Oman has introduced a program titled Sahim, a RE initiative to promote the use of solar energy. Through this initiative, residents are encouraged to install solar panels on their rooftops, and transport surplus electricity to the grid. In addition to this, Kuwait is also keen on diversifying the energy mix with the inclusion of renewable energy resources. Kuwait has set a target of 10%, and 15% of electricity generation from renewable resources by 2020, and 2030 respectively (IRENA, 2019).

Qatar has acknowledged the lack of progress in the field of renewables, and the need to include renewable energy in the energy mix to meet rising energy demands. So far, Qatar intends to reach production of renewable to 200MW by 2020, and 500MW from thereafter (Ministry of Development Planning and Statistics, 2018). Lastly within GCC, Bahrain has also developed National Renewable Energy Action Plan (NREAP) with the policy of increasing the share of RE in the energy mix. As per the NREAP, the targets defined for RE are 5%, and 10% for the years 2025, and 2035 respectively (SEU, 2017b).

2.5.3 Policies of RE in EU, & USA

As discussed in the technical section, EU, and USA have already enacted renewable energy policies back in 2009, and 2005 respectively. There were three main objectives of EU's directive of 2009: to promote and produce energy from renewable resources, 20% of EU's total energy shall come from renewable resources, and 10% of transport fuels should come through renewable resources. In EU's latest report for directive on renewable energy, it was highlighted that 17.52% of total energy demand was achieved from renewable energy resources, majority of the countries are on track to meet the renewable energy targets, but, EU members were able to achieve only 6% of transport fuels from renewable resources, and EU members would need to take significant measures to achieve the target (European Commission, 2019; Energy - European Commission, 2017).

However, this directive has gone under revision in 2018, EU has enacted revised renewable policies under the directive titled "Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)". Under the EU's revised directive of 2018, which belongs to the broader goal of EU i.e. Clean energy for all Europeans, EU has formed a binding agreement for renewable energy targets of 32% up from 20% with likelihood of scaling up the targets by 2023. Furthermore, all the members shall submit National Energy & Climate Plans for the period 2021-2030 explaining on the framework, and roadmap to achieve the renewable energy targets. Besides this, enactment of renewable polices is not enough at times. Quite often progress reports at regular intervals play a vital role in understanding the dynamics of policies in place, difficulties in achieving the defined targets, and crucial factors in achieving the role as a learning curve. In the past, EU has emphasized on progress reports, and continues to endorse the need of progress report. For example, the progress reports every other year to track the progress of renewable energy targets of 2009 identified that current practices by EU members are not enough to meet the goals 10% of transport fuels from renewable resources (Energy - European Commission, 2017).

Moving on, few other schemes encouraged, and promoted within the European Union are FiT, and Renewable Energy Certificates (RECs). In the earlier sections, some economic policies are discussed already. FiT is simply compensating the customer financially for providing the electricity generated from renewable sources into the public grid (Ramírez et al., 2017). Rates of financial compensation are decided by the authorities with rates correlated with the type of technologies/resources used to generate electricity. Then, the utility providers have an obligation to purchase the electricity from the renewable energy producer at the rates defined by the authorities, or above-tariff rates (Schaffer and Bernauer, 2014). FiT are considered as economically efficient because of the long-term monetary stability it gives to the investors (Lesser and Su, 2008). Due to monetary incentives, FiTs have led a positive drive towards increase in renewable energy production (Smith and Urpelainen, 2013).

However, governments often struggle to strike a balance between charging extra costs to electricity consumers, and maximizing investment incentives (Schaffer and Bernauer, 2014). Plus, the government subsidies on renewable energy without considering the public's viewpoint of taxes have often led to massive financial expenditures on the governments globally (Böhringer, Keller and van der Werf, 2013). Due to this, generous tariff rates, over capacity, and tariff deficits led to the discontinuation of FiT programs in Spain & Cyprus (Pyrgou, Kylili and Fokaides, 2016; Ciarreta, Espinosa and Pizarro-Irizar, 2014). In fact, Denmark, and Germany's markets have shown reluctance in new projects due to the introduction of low tariff rates (Pyrgou, Kylili and Fokaides, 2016).

REC also known as green certificates in Europe, are tradable certificates issued to the generator for producing 1MWh of renewable energy (Coulon et. al., 2015; Schaffer and Bernauer, 2014). For REC, quotas are imposed by the authorities on the electricity consumers, which must be achieved by the consumers (Schaffer and Bernauer, 2014). The producers/generator of renewable energy upon receiving the RECs can sell or trade these either to the load-serving entity that is subjected to produce certain of electricity from the renewable resources, or to meet the targets (Schaffer and Bernauer, 2014). This is considered as the most efficient mechanism of providing a given quota, or specific proportion of renewable energy under ideal market conditions (Menanteau et. al., 2003).

In USA, several renewable policies were enacted during the past two decades to encourage the use of renewable energy, increase the electricity generation through RE initiatives, and minimizing the reliance on fossil fuels for energy consumption. For instance, the enactment of Energy Policy Act 2005 paved way for renewable energy. In the Act, it was mandated that from the date of enactment, the government shall publish annual reports, highlighting the characteristics and inventory of RE, incentives to businesses that produce RE, implying renewable energy targets for electrical energy consumption of federal buildings, and lastly, use of PVs in public buildings (Energy Policy Act 2005).

Second, in 2009, American Recovery and Reinvestment Act of 2009 had also enacted RE friendly policies. For example, the electricity grids shall support the transmission of intermittent RE sources including the storage. Also, $16.8B of funds were allocated for energy efficiency and renewable energy under this Act (American Recovery and Reinvestment Act of 2009). Basically, the purpose of these funds is to provide loans, incentives, and necessary support for organizations endorsing RE programs. Third, the Renewable Portfolio Standards also played a vital role in transition towards RE. So far, total of 37 states have already adopted RPS goals (binding & non-binding agreements that require the electricity providers to provide a set share of electricity from renewable resources (Zhou, 2015).

Fourth, net metering policies are in place in more than 40 states that continues to stimulate the growth of RE (Zhou, 2015). Across the world, more than 50 countries have enacted various net metering policies for promoting solar energy (Davies and Carley, 2016). Net metering is simply the billing process in which the consumer is rewarded for transferring excess electricity generated from renewable resources to the grid; this reward can be by either spinning the meters in reverse or getting paid for excess energy provided to the grid (NREL, 2016; Dufo-López and Bernal-Agustín, 2015; Jordan, 2014). With this, consumers are encouraged to install renewable resources. Last, purchase of Renewable Energy Certificates (RECs) have also contributed towards the growth of RE i.e. tracking the electricity delivered to the grid for meeting customer demand (EPA, 2018).

RECs are often purchased by consumers, and several organizations who intend to diversity the electrical supply, minimizing the environmental impact due to their electrical consumption (EPA, 2018). Overall, due to the enactment of RE policies by the USA's federal administration, state-level administrations were encouraged, and concurrently enforced to adopt RE policies that led to the integration of RE in the electricity grid. Even though, renewable energy merely contributes 11% to the energy demand of USA, but, current policies will ensure the increase in contribution of RE to the energy demand.

2.5.4 Policies of Energy Efficiency in GCC

This section will discuss the energy efficiency policies that can contribute to ZEB. USA, EU, and GCC will be the focus of discussion. The following Table 1 is a summary of energy efficiency policies in the GCC. Bahrain's NEAAP has set a target of 5,800 GWh savings for the year 2025, and cumulative energy savings of 25,000 GWh for a nine-year period 2016-2025 (SEU, 2017a). Bahrain's building sector will be the primary contributor to energy savings. In addition to this, with the implementation of NEEAP, Bahrain expects to reduce the greenhouse emissions by 3.4M tons of CO_2 (SEU, 2017a).

Table 1: Energy Efficiency Policies & Initiatives

SN	Country	Energy Efficiency Targets	Policy/Initiatives	Local Authorities
1	Bahrain (SEU, 2017a)	reduction in energy consumption by 6% by 2025	National Energy Efficiency Action Plan	Sustainable Energy Unit
2	Kuwait (Energy Conservation Program Code of Practice; Kuwait Institute for Scientific Research, 2019)	improve electricity generation by 5%, and 15% by 2020, and 2030 respectively		Kuwait Municipality, Ministry of Public Works
		reduction in energy consumption by 30% by 2030	Energy Conservation Program	Ministry of Electricity & Water
3	Kingdom of Saudi Arabia (Saudi Vision 2030, 2017)	reduction in electricity consumption by 8% by 2021	Saudi Energy Efficiency Program, The Public Investment Fund Program	Sustainable Energy Efficiency Center
4	Oman (IRENA, 2019)	overall reduction in greenhouse emissions by 2% by 2030	Yaseer	Authority for Electricity Regulation Oman
5	Qatar (Ministry of Development Planning and Statistics, 2018)	reduction in per capita electricity by 8% by 2022	National Energy Management and Efficiency Programme (Tarsheed)	Ministry of Development Planning & Statistics
		reduction in water consumption per capita by 15% by 2022	National Energy Management and Efficiency Programme (Tarsheed)	Ministry of Development Planning & Statistics
6	United Arab Emirates (The United Arab Emirates' Government Portal, 2019; Department of Urban	energy efficiency of electrical appliances, and water fixtures	Emirates Energy Rating System	Emirates Authority for Standardization & Metrology
		one-pearl for public buildings two-pearl for residential villas	Pearl Building Rating System (Estidama)	Department of Urban Planning and Statistics

	Planning & Municipalities, 2010)	for all developments	Green Building Regulation	Dubai Municipality
		awareness of reduction in electricity & water consumption	Regulation and Supervision Bureau	Department of Energy
		demand side management in power, water, and transportation fuel	Demand Side Management	Dubai Supreme Council of Energy
		Dubai: reduction electricity consumption by 30% by 2030	DIES 2030	Dubai Supreme Council of Energy
		overall reduction in electricity consumption by 40% by 2050	UAE Clean Energy Strategy 2050	UAE Government

Like Bahrain, Kuwait does have an energy conservation program that highlights the minimum energy requirements for several types of buildings (Energy Conservation Program Code of Practice). The energy conservation program was initially introduced in 1983, and since then, the program has gone under several revisions over the past few years (Energy Conservation Program Code of Practice; Kuwait Institute for Scientific Research, 2019). Even though the program was first introduced 1983, the program was not implemented in an effective manner. As a result, the demand of energy continued to increase over the years (Kuwait Institute for Scientific Research, 2019). In addition to this, Kuwait’s energy efficiency targets in terms of energy savings, and reduction in greenhouse emissions are still unknown. However, by 2030, IRENA (2019) has stated that Kuwait shall minimize energy consumption by 30%.

Moving on to Saudi Arabia, Saudi Arabia has established Saudi Energy Efficiency Center for developing energy efficiency standards, and policies. In addition to this, as a part of the wider The Public Investment Fund Program, which is the investment arm of Saudi Arabia, the National Energy Efficiency Services Company was established with the key objectives of achieving significant energy savings, improving energy efficiency services by encouraging public-private partnerships, and job creation in the energy efficiency sector (Saudi Vision 2030, 2017). Before scaling these efforts in the commercial sector, in the first phase, the emphasis will be on the public buildings.

Similarly, Oman has recently launched the energy efficiency initiative called Yaseer in an effort minimize energy consumption, and Oman is keen on establishing energy efficiency services to retrofit, and audit public buildings. With these efforts i.e. Sahim and Yaseer, Oman intends to minimize energy consumption, and bring an overall reduction in greenhouse emissions by 2030 (IRENA, 2019).

In Qatar, National Energy Management and Efficiency Programme also known as Tarsheed was formed to raise an awareness of reducing energy consumption and minimizing carbon emissions (Ministry of Development Planning and Statistics, 2018). Qatar has set an overall energy efficiency target of 10% by 2022. In addition to this, Qatar has specific targets for water consumption per capita, and electricity consumption per capita of 15%, and 8% respectively (Ministry of Development Planning and Statistics, 2018).

Lastly, there are several energy efficiency policies enacted by UAE at a federal, and emirate level. On a federal level, to increase the use of energy efficient products, Emirates Authority for Standardization and Metrology has introduced labeling, and rating schemes of the electrical products, and water fixtures (The United Arab Emirates' Government Portal, 2019). These schemes fall under the Emirates Energy Star rating system that states the annual energy consumption on the product, stars to highlight the product's energy efficiency with 5 stars for the highly efficient product, and a star for the least efficient product (The United Arab Emirates' Government Portal, 2019). In addition to this, Emirates Energy Star is retrofitting existing buildings to achieve reduction greenhouse gas emissions, and energy savings of 10-35% (The United Arab Emirates' Government Portal, 2019).

Also, the federal government has approved measures for implementing green building standards and specifications across the country (The United Arab Emirates' Government Portal, 2019). As a result, the emirates of Abu Dhabi & Dubai have enacted the Pearl Building Rating System, and the green building regulations respectively. (The United Arab Emirates' Government Portal, 2019). The five-pearl building rating system rates the energy efficiency of buildings in terms of minimizing waste, electricity and water consumption, and use of local materials (Department of Urban Planning & Municipalities, 2010). For the ratings, all the public buildings, and residential villas must obtain one-pearl, and two-pearl ratings respectively. Whereas in Dubai, the green building regulation is compulsory for all buildings (The United Arab Emirates' Government Portal, 2019).

In addition to these, Regulation and Supervision Bureau, and Dubai Supreme Council of energy work with the residents, and entities to manage the electricity and water demand (The United Arab Emirates' Government Portal, 2019).

2.5.5 Policies of Energy Efficiency of European Union

Initially, by 2020, EU set the energy efficiency savings of 20% by savings from the EU's primary consumption. This was under the Energy Efficiency Directive titled "2012/27/EU" published in the year 2012. Later, in 2018, the energy efficiency targets were revised to 32.5% by 2030 with chances of revision in targets in 2023 under the amended Directive called "Amending Energy Efficiency Directive (EU) 2018/2002." EU identified renovation of the buildings as one of the primary factors that could potentially reduce the greenhouse emissions by up to 90% by 2050 with 1990 as a benchmark. Under the amended Directive of 2018, by the end of 2019, the EU members will submit their 10-year execution plan called

National Energy & Climate plans stating the measures to achieve the energy efficiency targets of EU. Several other directives such as the "Energy Performance of Buildings 2010/31/EU" were issued to meet the energy efficiency goal of EU. Table 2 is the summary of several directives enacted to achieve energy efficiency targets in the EU.

Table 2: Summary of Energy Efficiency in the EU

SN	European Union Directive	Targets
1	Energy Efficiency Directive (2012/27/EU)	20% of energy savings by 2020
2	Amending Energy Efficiency Directive (EU) 2018/2002	32.5% of energy savings by 2030
3	Energy Performance of Buildings Directive (2010/31/EU)	20% reduction in greenhouse emissions by 20% compared to emissions of 1990
4	Amending Energy Performance of Buildings Directive (2018/844/EU)	40% reduction greenhouse emissions by 2030 compared to emissions of 1990
5	Energy Labelling Directive (2010/30/EU)	in line with Energy Efficiency Directive of (2012/27/EU)

Moving on, as per the latest progress report of EU, in 2017, the leading sectors of energy consumption are as per the Figure 5. Transportation sector leads the energy consumption by 34% followed by industrial, and residential sector with 25%, and the remaining 16% is consumed by other services (European Commission, 2019).

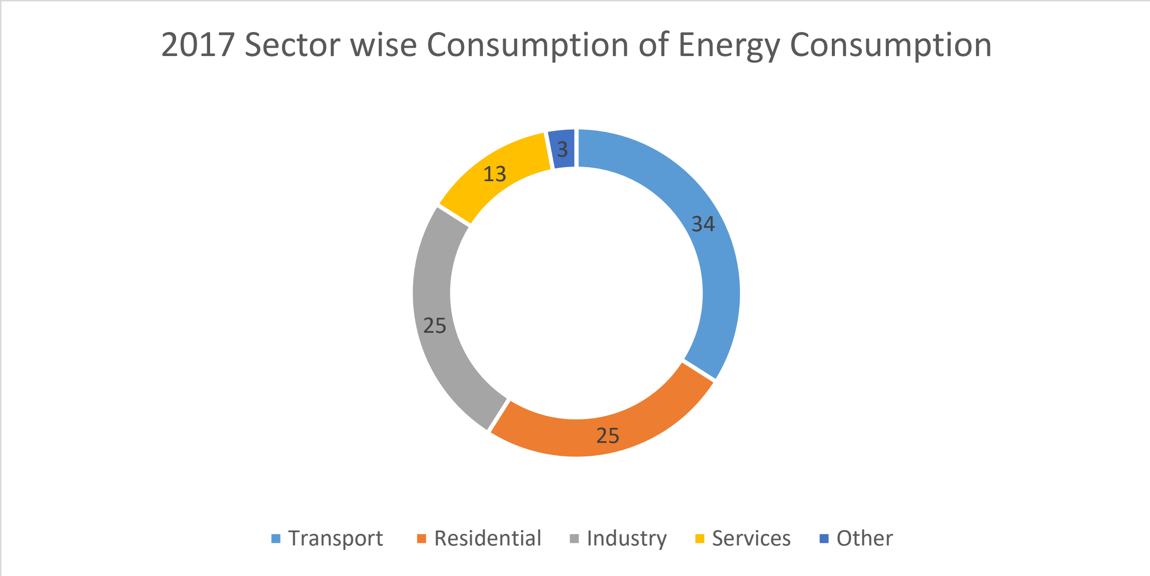

Figure 5: Sector wise Comparison of Energy Consumption in EU (European Commission, 2019)

In addition to this, EU report concluded that there is an increase in primary energy consumption from 2014 onwards, and if the consumption continues to increase, then, there is a risk of falling behind in achieving the targets. However, there were positives from the period of 2014 to 2016. More than half the members of EU were able to meet, or exceed the savings targeted for the period of 2014 to 2016. In fact, Finland has already achieved the energy efficiency target of 2020. The following figure highlights the countries in green that were able to achieve target of 2014-2016, and in red for those countries that failed to achieve their targets. However, the remaining members need to take significant energy efficient measures to achieve the set target. This is because majority of the members are yet to reach the halfway mark of the overall target set under Energy Efficiency Directive (European Commission, 2019).

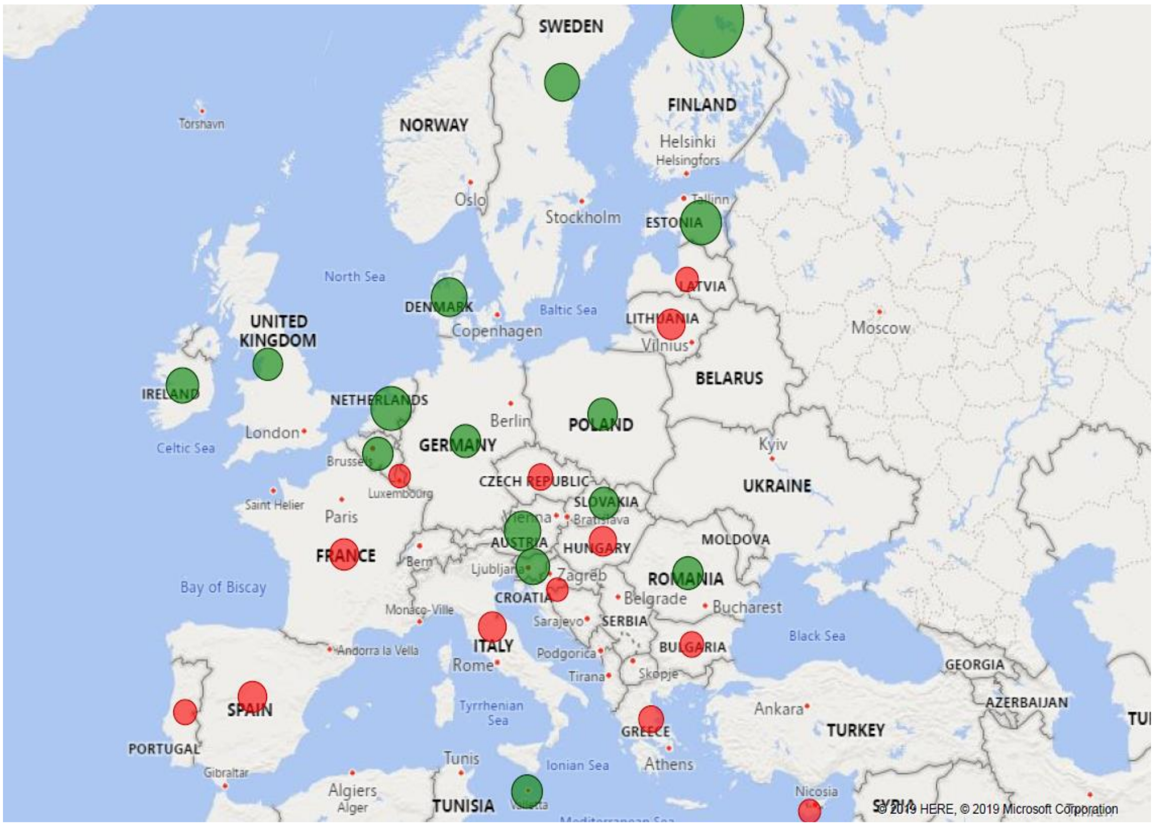

Figure 6: Progress of EU members during 2014-2016 (European Commission, 2019)

2.5.6 Policies of Energy Efficiency in USA

From a national perspective, the Energy Policy Act 2005, and Energy Independence and Security Act 2007 have touched issues of renewable energy, ZEB, and energy efficiency broadly. Besides this, there are several other policies of energy efficiency that have had significant savings in energy consumption. For instance, the Energy Star labeling program provides information about the product in terms of cost, and greenhouse emissions. The label is marked on the appliances, and equipment that helps consumers, and businesses in making wise decisions. In addition to this, the program is not limited to products only, the program is also available for homes (new construction, or existing), and commercial properties across USA (EPA, 2019).

Moving on to energy efficiency codes, the building codes are drafted by two independent organizations i.e. American Society of Heating Refrigeration Air-Conditioning Engineers

(ASHRAE) for commercial buildings, and International Code Council (ICC) for both commercial, and residential buildings (Cohan, 2016). These building codes are updated every three years for both residential, and commercial sectors with the primary purpose of establishing minimum energy efficiency targets (Cohan, 2016). In the first phase of code development, the public participates by submitting the proposals. These proposals are discussed in public hearings, and then, final voting by the committee members confirms the inclusion of accepted proposals in the revised code (Cohan, 2016). Once the revised code is published, as required by the Energy Conservation & Production Act, DOE has a year to review, and issue a letter of determination confirming that the revised code leads to greater energy savings in comparison to the previous code (Cohan, 2016).

Moving on from code development, the next phase is the adoption of the revised by the state governments. As USA does not have a national energy code that binds the state for compliance, adoption, or enforcement of the code is the sole responsibility of the states, or even local government (Energycodes.gov, 2013). Typically, the adoption of revised codes happens either by legislation measures, or through regulatory procedure i.e. an agency authorized by the state government to oversee the adoption phase (Cohan, 2016).

The last phase is simply complying and enforcing latest energy efficiency codes for achieving the intended targets in the adopted codes. Effective trainings, educating the industry about the latest codes, review of specifications, evaluation of materials, and field inspections are few examples of compliance (Energycodes.gov, 2018). In addition to these, to streamline compliance with latest model codes, DOE has developed compliance tools called COMcheck, and REScheck for the industry (Cohan, 2016).

The following table states the latest model codes in place for the commercial, and residential sectors. ICC has developed International Energy Conservation Code for both commercial, and residential sectors. Whereas, ASHRAE has developed ASHRAE 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings for commercial buildings only (Cohan, 2016).

Table 3: Latest Energy Efficiency Codes for Commercial and Residential Buildings in USA (Cohan, 2016)

Current Code	Commercial	Current Code	Residential
ASHRAE 90.1 - 2016	**Targeted Energy Savings:**	2018 International Energy Conservation Code	**Targeted Energy Savings:**
	8.2% of energy cost savings 7.9% source energy savings 6.7% site energy savings		1.97% of energy cost savings 1.91% source energy savings 1.68% site energy savings

Furthermore, DOE studied the impact of the energy codes in terms of savings, and reduction in CO_2 emissions across USA, and DOE estimates a cumulative cost saving of $126B, and reduction of 841 MMT of CO_2 emissions for a period of 2010-2040 (PNNL and DOE, 2016).

In this, DOE's role is to support the development, and implementation of the energy codes by reaching out to concerned authorities, and industry stakeholders. Second, DOE is responsible for providing technical expertise during the three-tier process of code development, adoption, and compliance. Third, DOE tracks the status of the energy codes of each state to understand the overall progress of the country. Last, upon publishing the revised, and written confirmation in the federal government's journal by the DOE that latest code will lead to further energy savings in comparison to the previous code, State governments have a two-year window to review the following (42 U.S. Code § 6833. Updating State building energy efficiency codes; Cohan, 2016):

- Residential Code: review and determine the need to update the provisions of the current code if required.
- Commercial Code: review and update the provisions of the current code to meet the latest ASHRAE 90.1, or IECC codes.

The Table 3 illustrates the versions of energy codes adopted by the state government (Office of Energy Efficiency & Renewable Energy, 2018). Till date, most of the states have adopted, or amended ASHRAE, or IECC's codes for energy efficiency of residential and commercial building except the following states where home rule is prevalent i.e. local governments govern the code adoption: Alaska, Arizona, Colorado, Hawaii, Kansas, Mississippi, Missouri, North Carolina, North Dakota, South Dakota, and Wyoming (Energycodes.gov, 2018). Besides this, California, Washington, Oregon have recently enacted energy efficiency codes instead of adapting to ASHRAE90.1, or IECC code. As far as the adoption of codes are concerned, only the state government of Nevada has adopted the latest ASHRAE90.1-2016, and IECC 2018 for commercial sector, and IECC 2018 with amendments for the residential sector so far. Referring to the table below, the states & codes marked in green correspond to residential sector only, states and codes highlighted in orange indicates unified code residential and commercial sectors, whereas, the gold color corresponds to codes of commercial sector only.

Table 4: State wide Codes of Energy Efficiency for Residential & Commercial Sectors (Office of Energy Efficiency & Renewable Energy, 2018)

State	2006 IECC	IECC 2009	IECC 2009 with amendments	IECC 2012	IECC 2012 with amendments	IECC 2015	IECC 2015 with amendments	2018 IECC	IECC 2018 with amendments	None statewide Codes	Home rule	2013 California State Code	2014 Oregon Residential/Energy Efficiency Specialty Code	2015 Washington State Energy Code	2018 IECC	ASHRAE 90.1-2004	ASHRAE 90.1-2007	ASHRAE 90.1-2007 with amendments	ASHRAE 90.1-2010	ASHRAE 90.1-2010 with Amendments	ASHRAE 90.1-2013	ASHRAE 90.1-2013 with Amendments	ASHRAE 90.1-2016
Alabama							✓														✓		
Alaska										✓													
Arizona											✓												
Arkansas		✓	✓														✓						
California												✓											
Colorado											✓												
Connecticut						✓	✓														✓		
Delaware				✓															✓				
District of Columbia					✓														✓				
Florida							✓														✓		
Georgia			✓														✓						
Hawaii											✓												
Idaho					✓	✓															✓		

Illinois							✓														✓		
Indiana		✓																✓					
Iowa				✓	✓														✓				
Kansas											✓												
Kentucky		✓		✓															✓				
Louisiana		✓															✓						
Maine		✓															✓						
Maryland						✓	✓														✓		
Massachusetts							✓														✓		
Michigan					✓		✓															✓	
Minnesota					✓														✓				
Mississippi										✓													
Missouri											✓												
Montana				✓	✓														✓				
Nebraska		✓															✓						
Nevada								✓	✓														✓
New Hampshire		✓	✓														✓						
New Jersey							✓														✓		
New Mexico		✓															✓						
New York						✓	✓															✓	
North Carolina							✓														✓		
North Dakota											✓												
Ohio		✓			✓															✓			
Oklahoma	✓		✓													✓							
Oregon													✓										
Pennsylvania						✓	✓														✓		
Rhode Island				✓	✓																		

South Carolina		✓															✓						
South Dakota											✓												
Tennessee			✓	✓															✓				
Texas						✓															✓		
Utah						✓	✓														✓		
Vermont							✓															✓	
Virginia						✓	✓														✓		
Washington														✓									
West Virginia		✓															✓						
Wisconsin			✓				✓															✓	
Wyoming											✓												

identical statewide codes for both residential & commercial sectors

statewide codes for commercial sectors

statewide codes for residential sector

2.6 Definition of ZEB in the Unites States of America (USA)

From a state point of view, there are a couple of definitions of ZEB that will be discussed. DOE defines the concept of ZEB as "an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable expected energy" (U.S. Department of Energy, 2015). As per the DOE (2015), use of the on-site renewable energy to offset the delivered energy is a must; where, on-site renewable energy is simply the energy produced by the renewable energy sources within a site boundary (U.S. Department of Energy, 2015). In addition to this, DOE also found out that the term "net" confused the consumers, hence, to promote and simplify the concept, DOE and New Building Institute (NBI) concluded that the term Zero Energy Building (ZEB) should be used moving forward (U.S. Department of Energy, 2015). This paper shall refer to net-zero energy, or zero net energy as ZEB. However, on a national level, the federal government of USA has a different understanding of ZEB. The government refers to such buildings as zero-net energy. The government of USA defines zero-net energy as "A building that is designed, constructed, and operated to require a greatly reduced quantity of energy to operate, meet the balance of energy needs from sources of energy that do not produce greenhouse gases, and therefore result in no net emissions of greenhouse gases and be economically viable" (The White House, 2009). Initially, the Executive Order was to enforce that all the federal buildings shall conform to new energy efficiency standards, and all the federal buildings that will undergo the planning phase from the beginning of 2020 onwards should be designed to be zero-net energy by 2030 (The White House, 2009). However the Executive Order was revised, and all the new construction of federal buildings greater than 5000 sq. ft. that enter planning phase from the beginning of 2020 and thereafter shall be designed to achieve net-zero, and if feasible, water or waste net-zero by 2030 (The

White House, 2015). In the revised Executive Order, net-zero energy building was redefined as well. Net-zero energy building was defined as a building that is designed, constructed, renovated, and operated in such a way that actual source energy consumption is balanced by on-site energy generation (The White House, 2015). Besides the integration of zero net energy in the federal buildings, the government of USA has also established benchmarks for commercial buildings under the Energy Independence and Security Act 2007. Under this, there are three zero-net energy goals set by the government; all newly constructed buildings will be zero net energy by 2030, 50% of the commercial building stock by 2040, and all the commercial buildings by 2050 (Energy Independence & Security Act 2007). As per the enactment, zero-net energy commercial building is defined that is designed, constructed, and operated at lower quantity of energy, balances the need of energy from sources that do not produce greenhouse gas emissions, no net greenhouse gas emissions, and economically viable (Energy Independence and Security Act 2007).

2.6.1 Definition of ZEB in California, USA

California Public Utilities Commission had called for new goals of establishing zero-net-energy building standards in the residential and commercial sectors by 2020, and 2030 respectively (California Energy Commission, 2013). In fact, in 2013, the Governor of California called for all new State buildings, and major renovations to be zero-net energy after 2025 (California Energy Commission, 2013). For existing state buildings, at least 50% of square footage should achieve the state of zero-net energy by 2025 (California Energy - Commission, 2013). In fact, the framework and action plan are already in place to achieve zero-net-energy status from new residential buildings beginning from 2020 (California Public Utilities Commission, 2015). Regarding commercial buildings, the plan and strategy are not yet established to meet the above-mentioned goals. California Energy Commission

(2013) defines zero-net-energy as a building where the net amount of energy produced by the on-site renewables is equal to the energy consumed by the building on an annual basis. In addition to this, the target zero-net-energy building shall be achieved by focusing on but not limited to the following: increase the efficiency of new buildings by 20-30%, relevant training and incentives to achieve the zero-net-energy status and monitoring the construction and performance of zero-net-energy buildings (California Energy Commission, 2013). The definition established by the state of California is consistent with the definition of DOE (California Energy Commission, 2013; U.S. Department of Energy, 2015). However, there is a lack of consistency in the terminologies used on a federal, and state level, which is also evident in the literature i.e. zero-net-energy, and zero energy buildings.

2.6.2 Definition of ZEB in Cambridge, Massachusetts, USA

Like California, the city of Cambridge in Massachusetts, USA had introduced a 25-year plan to become a city with net-zero emissions from the building sector (Net Zero Task Force, 2015). The Task Force assigned with this endeavor defined net-zero as a community of buildings where greenhouse emissions during building operations are offset by carbon free production on an annual basis (Net Zero Task Force, 2015). City of Cambridge has targeted 2022, and 2025 for all new residential, and commercial buildings to achieve net-zero status, respectively (Net Zero Task Force, 2015b). To determine the progress, and to amend standard if necessary, the state authorities have published annual reports as well (Net Zero Task Force, 2018). In the annual progress, it was highlighted that buildings are already in the process of incorporating of energy efficiency (Net Zero, 2017; Net Zero Task Force, 2018). To sum up, Cambridge has laid out the framework to become a net-zero city by focusing mainly on the energy efficiency standards, net-zero new construction, renewable energy supply, local carbon fund i.e. purchases of carbon offsets and credits, and engagement and capacity building (Net Zero Task Force, 2015a). The definition adopted by the City of Cambridge is different than the definitions discussed above (Net Zero Task Force, 2015; California Energy Commission, 2013; U.S. Department of Energy, 2015). This is because the City of Cambridge has defined net-zero on a city level and, and the state of California has defined zero-net-energy in terms of building sector. But even then, City of Cambridge's definition does not coincide with the definition of DOE where emphasis is on the on-site renewable energy in lieu of the carbon offsets, or renewable energy certificates (Net Zero Task Force, 2015; U.S. Department of Energy, 2015)

2.6.3 Definition of ZEB in Oregon, USA

Moving onto Oregon, the rise in ZEB in this state is primarily due to the state level policies that are addressing reduction in carbon emissions by focusing on ZEB. Like California, an Executive Order was issued to establish aggressive timeline to enact net zero energy buildings as a widely accepted practice. As per the Executive Order, the state of Oregon intends to reduce the greenhouse emissions by 10% and 75% to levels of 1990 by 2020 and 2050 respectively (Office of the Governor State of Oregon, 2017). Oregon expects to meet these ambitious goals by a combination of energy efficiency, use of electric vehicles, and renewable energy (Office of the Governor State of Oregon, 2017). Another factor is the engaging the market by providing incentives of adopting ZEB across all building sectors i.e. residential, commercial, and industry & agriculture, and encouraging renewable energy, energy efficiency, and energy-conservation efforts of low-income housing and K-12 schools including net zero programs (Oregon Department of Energy, 1999; U.S. Department of Energy, n.d.). Oregon Public Utilities Commission had engaged non-profit organization to administer the programs (U.S. Department of Energy, n.d.). The goal for net zero buildings are mutually agreed between the developer, and the non-profit organization, which are followed with stage wise incentives and resources deemed as appropriate. In 2007, the state of Oregon had enacted that 8% of retail electrical loads shall come from renewable resources (Oregon Renewable Energy Act). Effective policies and market engagement have act as a catalyst for adoption and transition towards ZEB.

2.6.4 Definition of ZEB in Arizona & New York, USA

The state of Arizona does not have codes in place for ZEB on a state level. However, City of Tucson, Arizona has sponsored the Net-Zero Building Energy Standard, and the officials are encouraging ZEB. For this reason, Arizona was one of the five leading states for supporting ZEB (New Buildings Institute, 2018). Moving onto New York, New York State Energy Research and Development Authority (NYSERDA) aids builders, and developers for single house, and multi-family buildings that are designed to achieve net zero energy performance. Design of the buildings must consider the following: use of renewable energy resources, and high-efficient appliances, and HVAC equipment (NYSERDA, 2019). Even though the states of Arizona and New York are providing support for ZEB, there are no legislations, or roadmap that provides a framework for acceptance of ZEB in entirety. But, examples of ZEB in these states validate that these states are taking measures in minimizing energy consumption.

2.6.5 Overall Progress of ZEB

In USA alone, there is a steady growth of zero energy buildings. As per the latest report of New Building Institute (NBI), there are 482 buildings registered or classified as Zero Energy Verified, or Zero Energy Emerging respectively (2018). Zero Energy Emerging buildings are referred to those buildings that are yet to be occupied, occupied for less than a year, or occupied for more than a year but not verified as zero energy (New Buildings Institute, 2018). Within USA, California is at the forefront of transition towards ZEB with 214 buildings followed by Oregon (24), New York (17), Arizona (16), and Massachusetts (15).

Another important finding worth discussing is the building sector. Education, and office sectors were the leading ZEB market segment (New Buildings Institute, 2018). In fact, the ZEB were constructed in extreme climate zones varying between 1A-7, however, majority of the ZEBs are in between the 3A-3C, and 4A-4C (New Buildings Institute, 2018). Further to this, in an earlier study of DOE & NREL of 2006, approximately 64% of the buildings had the potential of being ZEB by 2025 (Griffith et. al., 2006). Keeping the potential of ZEB in consideration, policy formation has led to the implementation of ZEB, but USA is still lagging in achieving the true potential of ZEB. Besides USA, several countries such as Canada, EU countries, and Japan have launched ZEB initiatives (Wells et. al., 2018; Pan and Ning, 2014)

2.7 Definition of ZEB in the European Union (EU)

On the other hand, to tackle the challenge of climate change, EU has also defined the ZEB under the legislation titled Energy Performance of Buildings Directive (EPBD). However, EPBD definition of ZEB is slightly different than DOE's definition. DOE has established stringent rules where the delivered energy to a building is completely by the building's on-site renewable energy sources. EPBD's definition of ZEB is for nearly zero energy buildings "The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources including energy from renewable sources produced on-site or nearby" (Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings). From the definition EU is willing to accept renewable energy sources beyond the site boundary to meet the energy demands. Moreover, the EPBD also stated that all new buildings occupied and owned must be nearly ZEB by 2020, and all public buildings occupied and owned by the end of 2018 (Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings).

2.8 Goals of United Arab Emirates (UAE)

In UAE, there are several strategies in place to combat climate change with emphasis on clean energy (Dubai Electricity and Water Authority, 2017; Ministry of Climate Change & Environment, n.d.; Ministry of Energy & Industry, 2017). Dubai, one of the seven emirates that make the UAE, has launched Dubai Clean Energy Strategy 2050 with an aim to produce to 75% of its energy from clean sources (Dubai Electricity and Water Authority, 2017). Initially, there are targets in place for clean energy in the Dubai Integrated Energy Strategy 2030 (DIES 2030). As per the DIES 2030, 7% and 25% of total energy shall come from clean sources by the years 2020 and 2030, respectively (Dubai Supreme Council of Energy, 2017).

Moving back to Dubai' 2050 Clean Strategy, Dubai plans to reach this goal by focusing on infrastructure, legislation, funding, capacity building & training, and environmentally friendly energy mix (Government.ae, 2018). First, infrastructure is primarily to generate energy from renewable sources such as solar energy (Government.ae, 2018). Second, provide framework and policies that will encourage use of clean energy. Third, training is referred to collaboration with international and local agencies to improve and prepare the labor force for clean energy sector. Forth is the establishment of a green fund that will assist investors in easy loans at lower interest rates. Last, environmentally friendly mix is mainly to increase the energy generation from clean energy sources such as solar energy, clean coal, nuclear, and gas (Government.ae, 2018). With no policies in place for ZEB, the purpose of this paper is to focus on the legislation pillar that will contribute to the goals of clean energy.

On the federal level, in 2017, UAE enacted the UAE Energy Strategy 2050 with primary goal of increasing energy mix of clean energy from 25% to 50% by 2050, which shall lead to potential savings of AED 700B (Ministry of Energy & Industry, 2017). With the UAE Energy Strategy 2050, UAE intends to reduce carbon footprint of power generation by 70% (Ministry of Energy & Industry, 2017). Also, the strategy will assist in increasing consumption efficiency of the public and corporate sector by 40% (Ministry of Energy & Industry, 2017). To meet UAE's demands of sustainable growth and environmental goals, the governments has goals of increasing energy mix of clean energy in the following: 44% clean energy, 38% gas, 12% clean coal, and 6% nuclear (Ministry of Energy & Industry, 2017).

2.9 Governance strategy

Besides the policies of ZEB, the governance structure, or the governance models are equally vital for ZEB policy implementation, the models vary geographically, and these are central to policy adoption for achieving policy outputs & outcomes, in this case ZEB targets (Zhang et al., 2016). Zhang et. al. (2016) have discussed the governance models of Denmark, California, and China thoroughly. Before the paper dives into the governance strategies of the countries, the paper will discuss the definition, and highlight the primary governance models that exist in the literature. Governance is simply defined as the deployment of means to streamline and manage a region's economy and society, where all the segments work collaboratively to achieve unified goals (Zhang et. al., 2016; Pierre and Peters, 2000). Governance modes can either be hierarchical (state-centric), market (society centric), or hybrid which is often the governance mode across the globe (Zhang et. al., 2016; Karin Bäckstrand. et al., 2010). Even though there are several aspects such as political, and constitutional associated to governance modes (Treib, Bähr and Falkner, 2007). This paper will only focus on the relation of governance mode, and policy making of ZEB.

2.9.1 Denmark

The parliament of Denmark is responsible for legislation, whereas, the executive powers are with the government, and the local municipalities. Typically, the framework i.e. establishing codes, instructions, and guidelines are the sole responsibility of the government, and municipalities are liable for implementation at a local level, and most often, these municipalities are facilitating the public (DEA, 2015). Further to this, another important role played by the government is the engagement with the stakeholders such as the municipal authorities, contractors, engineering consultants, academic professionals, non-profitable organizations, and manufacturing industry for constructive feedback on the regulations under preparation (DEA, 2015).

The governance mode in Denmark is a combination of hierarchy, market, and network forms (Zhang et. al., 2016). First, from a regulatory perspective, the central, and the local bodies are aware of their responsibilities for energy planning (Sperling, Hvelplund and Mathiesen, 2011). This is vital for communication, information sharing, and paves way for coherence in enacting ZEB policies (Zhang et. al., 2016). In addition, this exhibits that central and local authorities agree of the central government's overall goals. The local municipal authorities have an influence on the enactment of certain regulations of the national regulations (DEA, 2015). The combination of hierarchy and network governance mode ensures the ZEB goals backed by the Denmark's parliament are endorsed by the local municipalities, and the interdependent actors work towards achieving a common objective. Second, economic policies such as the taxes, subsidies, feed-in-tariffs, and net-metering have allowed the Danish society to shift towards ZEB (Zhang et. al., 2016; DEA, 2015;

Poullikkas, 2013). Third, technical policies such as establishing the building codes, identifying the building sectors i.e. new & existing buildings, labeling schemes, RE deployment such as PVs, and electricity and heat production systems have also motivated the people of Denmark to adopting ZEB goals (Ramírez et al., 2017; Zhang et. al., 2016). Economic policies of Denmark are an example of market-driven governance mode, which supports the society especially the private sectors to imbibe on strategies of the government

2.9.2 California

In USA, the energy codes, and standard are state-level concerns, and these are enacted by the state, and local municipal authorities. If required, US DOE provides technical support for building energy code programs to local authorities (Energy Conservation and Production Act [Public Law 94–385, as Amended]). Furthermore, there are no national energy codes in USA, and several energy efficiency targets enacted by the federal administration were limited to federal buildings only (The White House, 2015; DOE, 2013; The White House, 2009). On the other end, building targets such as zero-net energy goals were set through several acts such the EISA 2007, and Energy Policy Act 2005. As far as the adoption of policies is concerned, these can occur either through legislative, or regulatory process. In regulatory process, a committee of affected parties, and construction professionals assess, and provide recommendations before codes and standards become law.

Zhang et. al. has highlighted that market-based governance mode is predominantly driving the ZEB adoption in California (2016). For instance, from an economic perspective, tax credits, low-interest loans, rebates, negligible up-front costs, and net-metering have driven the markets of ZEB in California (Zhang et. al., 2016; California Public Utilities Commission, 2015). In fact, Darghouth et. al. (2011) have already discussed the cost savings because of encouraging net-metering in California. To say that the market-driven governance is correlated with the increase in ZEB in California would not be wrong. As mentioned in earlier sections, California is already leading the market with highest number of ZEBs (New Buildings Institute, 2018). From a technical perspective, compliance to building efficient standard such as Title 24, renewable portfolio standards, voluntary targets such as the Energy Star, ASHRAE Building Energy Quotient programs have ensured that the public has enough opportunities to comply with codes that conform to ZEB and assist in transition towards ZEB. Furthermore, campaigns, trainings, and tools to empower the people with decision-making abilities has raised the awareness, and the need of ZEB in California. In fact, one of the guiding principles of the zero net energy framework of California is titled as market driven that serves to achieve awareness amongst the public and provide education and trainings zero net energy buildings (California Public Utilities Commission, 2015). Besides market-based governance, hierarchical, and network-based governances are also evident in USA. To give an example of hierarchy, the zero-net energy goals were enacted by the federal administration under the Energy Independence & Security Act 2007 for the commercial buildings across USA. As a result, all the federal buildings shall conform to the federal targets. Often, the states or local municipalities regulate stringent procedures, and embark on achieving higher targets. For example, in California, the energy efficiency requirements of the buildings in the Title 24 are more stringent than the federal requirements of energy efficiency i.e. International Energy Efficiency Code (2015), and ASHRAE 90.1-2013 (California Energy Commission Approval Staff Report Detailing the Energy Efficiency Comparison between the 2016 Building Energy Efficiency Standards and ASHRAE/IESNA Standard 90.1-2013; California Energy Commission, 2015; DOE, 2014). Moving on, engagement of public & multi-stakeholders, and coordination federal and local authorities (Zhang et. al., 2016; California Energy Commission, 2015).

2.9.3 China

In China, the ZEB concept is relatively new with limited examples of pilot projects demonstrating the ZEB concept (Zhang et. al., 2016). Due to massive surge in energy demand, by 2030, the building codes under the energy conservation strategy require the commercial, and residential buildings to be 79%, and 82% more efficient than the baseline performance of the 1980s (Zhang et. al., 2016; Feng et al., 2016). In addition to the above, over the years, first in 2006, and then in 2014, the Chinese government has worked extensively developing standards of green buildings where the promotion of constructing ultra-low, and near ZEB building nationally is one of the components (Ma et. al., 2019; Zhang et. al., 2018). To emphasize, there are no codes of ZEB, and due to recent introduction of ZEB, Chinese market is devoid of certifications, tools, learning & development (Zhang et. al., 2016). Furthermore, Ma et. al. (2019) have highlighted the need to further develop these standards to encourage green buildings in China as a whole.

About the building codes, hierarchical governance is dominant in the China (Zhang et. al., 2016). For building energy codes, legislation process is a three-step process: national laws, regulations of the state council, and department rules, standards & planning (Yuan et al., 2017). First, national laws are issued by the highest authority of China in the form of presidential order. Then, the regulations of the state council are issued in the form of State Council Order. Whereas, department rules, and standards are approved by the ministries, and departments where the responsibilities are assigned to the ministries by the State Council (Yuan et al., 2017). Even though State Council is the higher authority in the hierarchical structure, within the third level of legislation, there is evidence of network-based governance as well. For instance, several ministries such as the Ministry of Housing and Urban Rural Development, Ministry of Finance, and Ministry of Industry and Information Technology (MIIT) issue standards, assessments, and guidelines pertaining to energy conservation through collaborative approach (Yuan et al., 2017). Later, in the discussion section, the case of the UAE will be discussed as well.

2.10 Regulatory Barriers of ZEB

From regulations' perspective, there are several barriers that hinder the implementation of ZEB. For example, standards to implement ZEB concepts are missing in the societies (Zhang et. al., 2016; Lindkvist et. al., 2014; Pan and Ning, 2014; Marszal et. al., 2011). Then, the subsidies on the energy prices are seen a barrier for ZEB (Khondaker et al., 2016; Krarti and Ihm, 2016). With subsidies on the energy prices, the end-user does not see a reason in conserving energy. Literature highlights that to ensure the competitiveness of ZEB, energy prices need to increase on annual basis (Matthew and Leardini, 2017; Leckner and Zmeureanu, 2011; Audenaert et. al., 2008). Another barrier is the existing policies and standards that hinder the implementation of ZEB (Matthew and Leardini, 2017; Pan & Ning, 2014). This is applicable for places where ZEB standards do, or do not exist. The existing standards either conflict with the ZEB codes, or not as stringent as ZEB's requirements. As one would expect, professionals will lean towards pursuing less stringent measures that are less costly, and easier to implement. Therefore, existing building codes must coexist with the ZEB codes. Also, one of the reasons for this hinderance is the lack of legal framework, and legislations that enforce the practice of ZEB's principles. As discussed in earlier sections, only USA, EU, and Japan have enacted ZEB specific policies. In fact, in Japan, Tokyo is encouraging policies that eliminate waste, and reduce greenhouse gases responsible for global warming (Fujita and Hill, 2007). However, partisanship on environmental issues is obstructing to transit towards such policies in Japan (Fujita and Hill, 2007).

2.11 Challenges in Implementing ZEB Policies

In the literature, it is seen that challenges in implementing ZEB policies are discussed as well. One of the predominant challenges seen in this case is the lack of unified definition widely accepted. For instance, as seen in the case of USA, and EU, there are different definitions of ZEB i.e. Zero Net Energy, and nearly Zero Energy Buildings. Another challenge associated with the acceptance of the unified definition is the on-site generation of energy to meet the requirements of high-rise buildings (Zhang et. al., 2016; Kibert, 2012). In USA, definitions insist on having on-site generation, whereas, the EU's definition is not that stringent. For high-rise buildings, to generate enough on-site energy generation, high-rise buildings will require significant site (Kibert, 2012). Third challenge is the willingness to pay higher rental, or sale prices for ZEB, and energy efficient buildings (Matthew and Leardini, 2017; Lindkvist et. al., 2014; Pan and Ning, 2014). To convince an end-user to occupy a relatively expensive ZEB than conventional building will prove to be a challenge. With longer payback periods, as a tenant, one can argue the need to move to an efficient building that does not payback for a significant. The same goes for homeowners as well i.e. the need to buy a house an expensive house in comparison to the conventional buildings. Lastly, finding a synergy between the existing codes, and the ZEB codes will be a challenge (Pan & Ning, 2014). The set of requirements associated with the ZEB are certainly stringent. At the time of introducing ZEB codes, there is a likelihood that existing building codes will hinder the integration ZEB codes. Also, there are chances of professionals falling will abide by the codes, and standards that are easier to adapt, and incorporate. Hence, challenge will remain around the synergy between the ZEB, and less stringent building codes and standards.

Chapter 3 – Results & Analyses

This section discusses the barriers in implementing ZEB policies in the UAE. From the literature, 30 barriers were identified, and these were categorized in four groups: technical, economic, social/cultural, and legislative barriers. This formed the basis of the survey for evaluation.

3.1 Survey

The survey was divided in three sections with first section requesting general information about the respondent such as the years of experience, role of the company, sector, type of residence, and size of the property. Table 5 is the summary of the questions asked in the first section:

Table 5: General Information

1	Please select your range of working experience in the construction industry
	0 - 5 years 5 - 10 years 10 - 15 years greater than 15 years
2	Your company is:
	Local Office International Office
3	Role of your company
	Contractor Designer/Architect Project Management Consultants Client Other (if other please specify)
4	Working Sector
	Private Public
5	Type of Residential Property
	Rental Contract Home Owner
6	Size of the Residential Property
	0 - 1000 sq. ft.

		1000 - 2000 sq. ft. greater than 2000 sq. ft.

In the first section, questions such as the experience of the respondent in the construction industry, part of public or private sector, type and size of the residence. The type and size of the residence helps in understanding the questions of the section 3 such as awareness of existing RE, and EE practices in the UAE.

Second section focused on the barriers in implementing ZEB policies. As mentioned above, barriers were grouped in the following four categories: technical, economic, social/cultural, and legislative. In this section, the respondents were asked to determine their agreement with the identified barriers to implement ZEB policies on a Likert scale of 1 to 5 with 1 corresponding to Strongly Disagree, and 5 corresponding to Strongly Agree. Table 6 contains the summary of the barriers grouped under the above-mentioned categories.

Then, the respondents were asked to rate the challenges in implementing ZEB policies on a Likert scale as well. From the literature, five challenges were identified, enough on-site generation for high-rise buildings, consensus on a universally accepted ZEB definition, willingness to pay a higher price, or rental price for ZEB and EE buildings, and synergy between ZEB and existing building codes. The respondents were asked to rate the challenges in implementing in ZEB policies on a 5-point Likert scale as well with 5 corresponding to Strongly Agree, and 1 point being strongly disagree.

Moving on, the third section was about the existing RE, EE policies, and prospects of ZEB in the UAE. The awareness, and practices of the respondents with respect to adopting RE, and EE policies in daily life were measured in mainly closed responses of yes, and no. Lastly, the respondents were asked about the type of building sector the potential have of achieving ZEB status, and state the building sector that can be the early adopter of ZEB policies in UAE.

3.2 Data Collection

The survey was primarily distributed within the construction industry through electronic mail, and the survey generated 34 responses in total. Microsoft Forms was used to create and distribute the survey. Therefore, the following analyses are based on the 34 responses obtained from the respondents. The responses obtained were a mix of contractors, consultants (architects, engineers, and designers), project management consultants, and government employees. The breakdown of the respondents is as follows: 15% were contractors, 18% were either architect or engineers, 30% each are Project Management Consultants and others, and 9% of the respondents are the client. To highlight, the others are either government officials, regulators, academic, or energy auditors and consultants. Furthermore, all the respondents were employed in the construction sector of the UAE. Only the respondents in UAE were shortlisted because the primary focus is on the policy-making decisions of the UAE, and it is of utmost important to obtain results from professionals who have prior experience, or currently apart of the UAE construction workforce. Figure 8 illustrates the no. of respondents, and their corresponding construction sector. Moving on to the experience of the respondents, 12 respondents are within the experience of range of 0 – 5 years, 8 respondents are between 10 – 15 years, and 7 respondents each are between 5 – 10 years and greater than 15 years of experience respectively. Figure 7 is a breakdown of the respondents based on their years of experience. The years of experience assist in determining the feedback of the recently graduated professionals against the experienced professionals. In terms of working sector, 19 of the respondents are in the private sector (56%), and 15 are working in the public sector (44%).

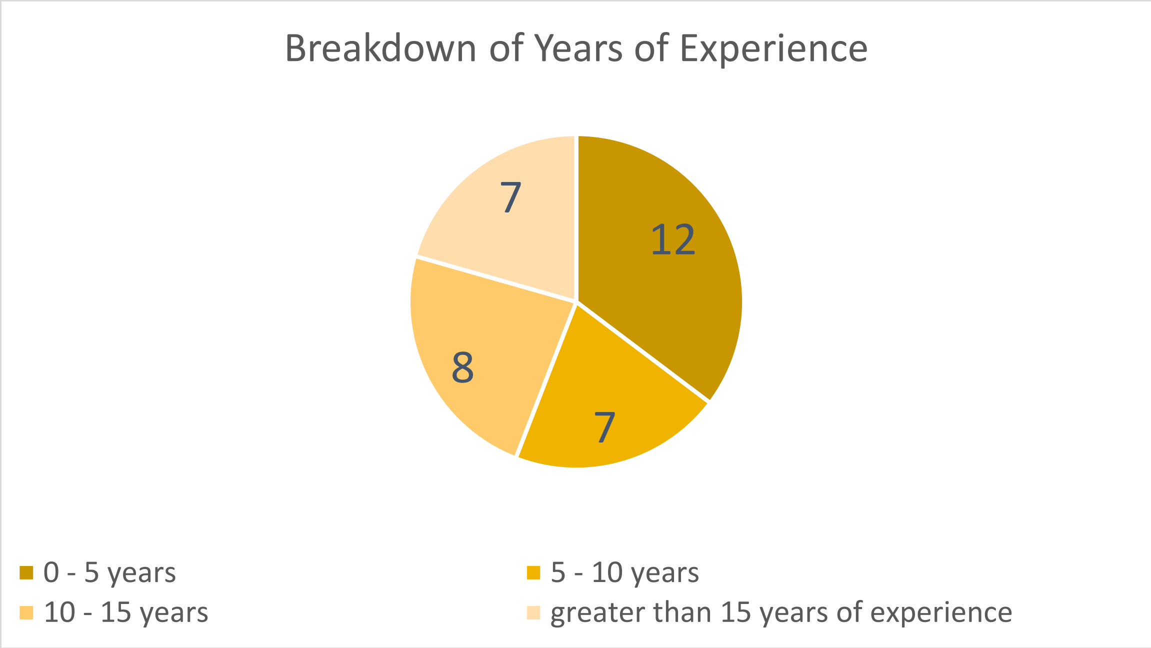

Figure 7: Years of Experience and No. of Respondents

In addition to this, regarding the type of residential property of the respondents, the feedback is as follows: 11 of them were home owners i.e. 32%, and the remaining 23 respondents (68%) were living as tenants in the UAE. The type of residential property will determine the role of the respondents in daily sustainable practices.

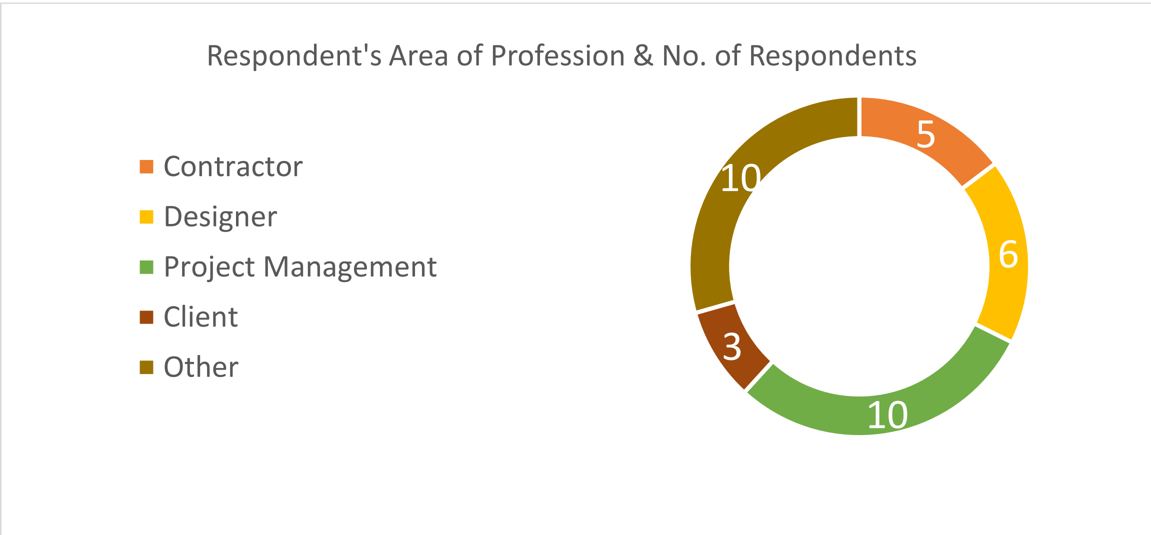

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Figure 8: Respondent's Area of Profession

Furthermore, in the closed responses section of awareness and practices in the UAE, there is a consensus in the respondent's feedback. Figure 9 depicts the responses for sustainable practices in the UAE. For instance, first, on being asked regarding the use of renewable energy to reduce electricity bills, 82.4% of the respondents were not taking advantage of the Shams solar program. Second, 56% of the respondents were aware of the solar water heater requirements in the buildings, however, 24% and 18% of the respondents were complying with the requirements, or unaware of the solar water heaters in their residences respectively.

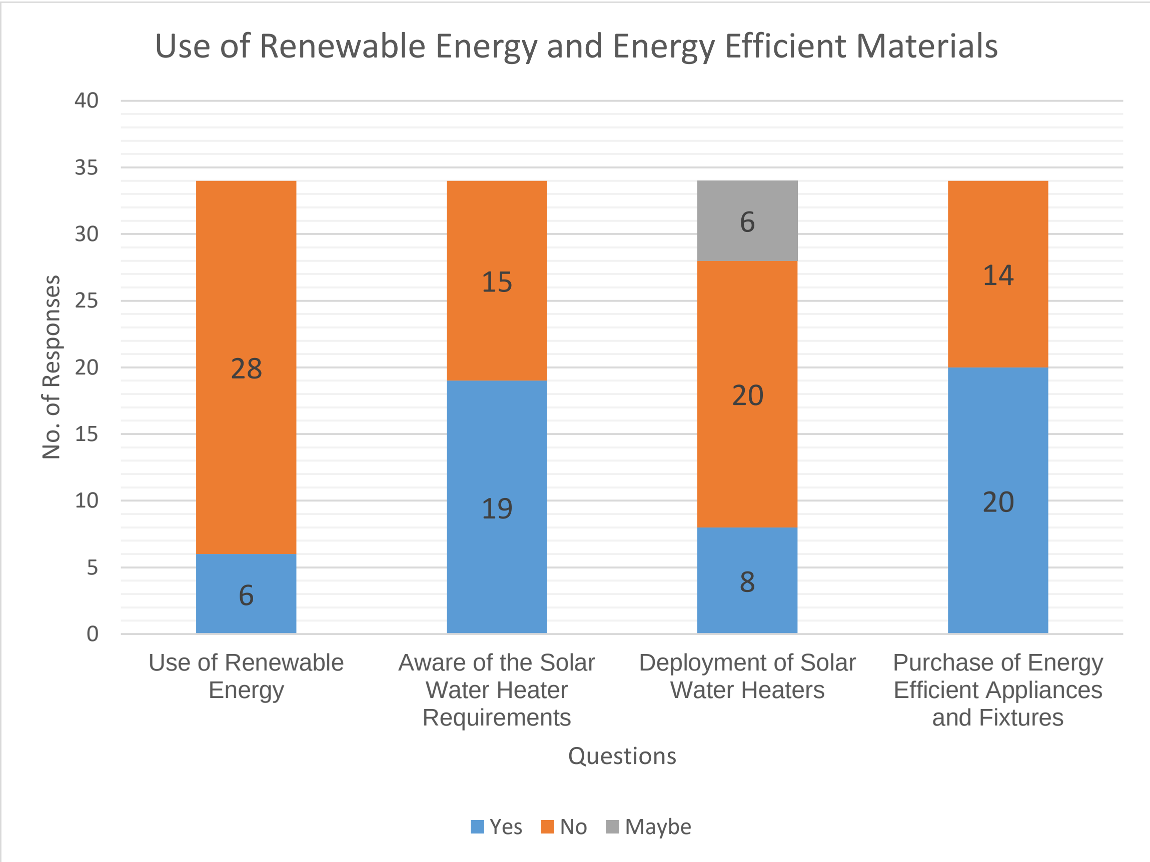

Figure 9: Responses on the Use of Renewable Energy, and Energy Efficient Materials

Third, as a follow-up to the requirements of solar water heaters, the respondents were posed with the question about the deployment of solar water heaters in their building of residence. Almost two third i.e. 20 of the responses were negative, 8 of the responses were positive, and the remaining 4 respondents were unaware. Fourth and last, on being asked regarding the purchase of energy efficient fixtures, and appliance, the responses were equally divided i.e. 59% do look for the rating system, and the remaining respondents often purchase without looking for the Emirates Energy Rating system.

In addition to the above set of questions regarding the sustainable practices, respondents were also asked to respond to questions pertaining to applying principles of ZEB. For example, 12 of the respondents were adamant on relying on-site renewable energy generation only. Whereas, 13 of the respondents were not keen on relying on the on-site renewable energy only. And the remaining 9 respondents were unsure about the reliance on the on-site renewable energy. Furthermore, respondents were asked to identify the type of building projects that have the potential of achieving ZEB status, and the respondent are certain that all types of projects have the potential of achieving of ZEB. Figure 10 is the summary of the responses for the question on types of building projects that can achieving ZEB, and reliance on generating on-site renewable energy resources.

Lastly, respondents were asked about the retrofitting a building, and new construction for the ZEB in terms of priority of the local governments. Half of the respondents i.e. 18 respondents believe that government can prioritize both retrofit, and new construction for ZEB simultaneously. On the other hand, 14 respondents believe that government can prioritize new construction only, and the remaining 2 respondents were in favor of retrofitting buildings only.

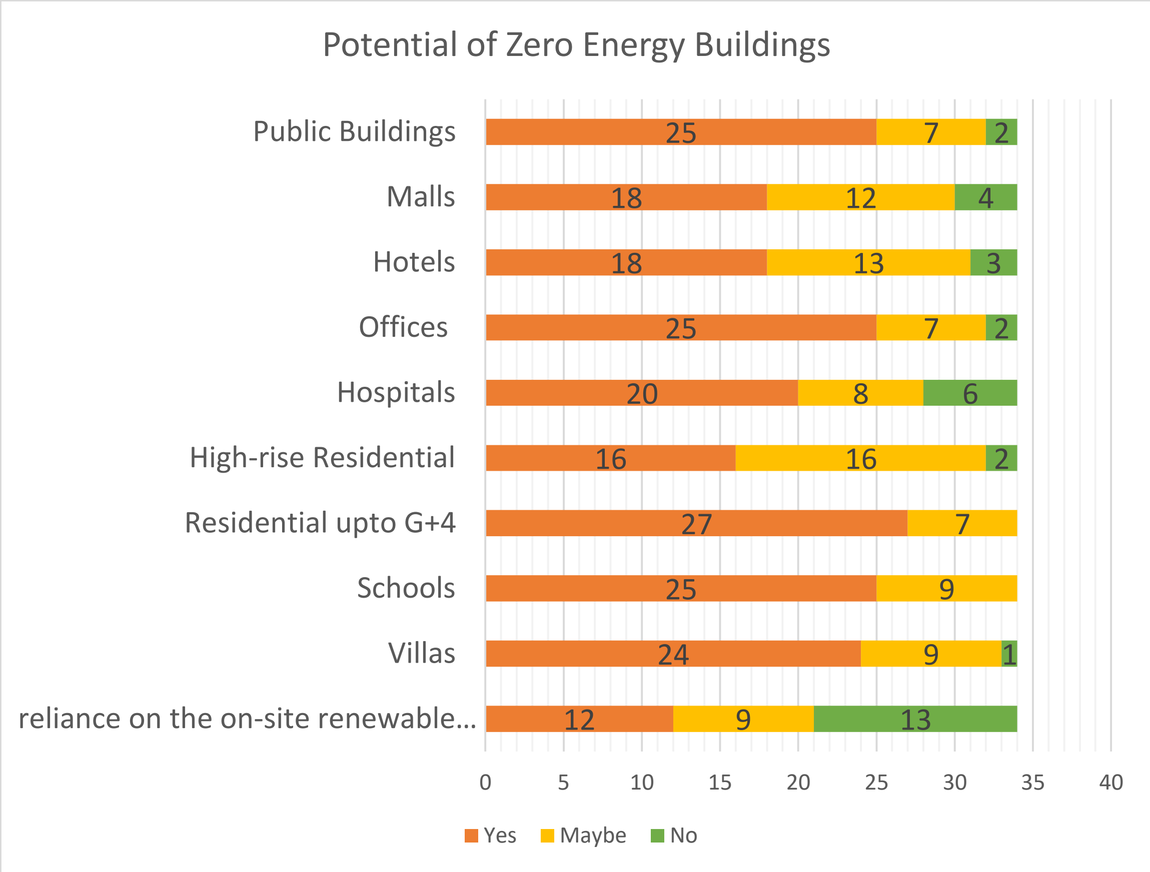

Figure 10: Potential of ZEB

3.3 Analyses

Through analyses and comparison, the purpose is to rank the barriers from the list of 30 identified barriers using the mean score method. The method was used by Chan and Kumaraswamy (1995), Chan et. al. (2003), and Amasyali and El-Gohary (2016) for identifying reasons of delays in construction projects across construction sectors i.e. contractor, consultant, and the client, and satisfaction of residential and office buildings in the USA (Chan et. al., 2003; Chan and Kumaraswamy, 1995). After this, overall rankings were compared with the rankings of the following: private & public sector, contractor, designers/architect and project management consultants, years of gained experience, and type of rental contract.

Kendall's Coefficient of Concordance and Spearman's rank correlation (r_s) analyses were used to assess the rankings of the barriers i.e. similarities and agreements for the stated set of comparisons. The Statistical of Social Sciences (SPSS) statistical package was used to assess the results. Kendall's Coefficient of Concordance (W) measures the level of agreement of different parties' rankings of barriers within the individual group on a scale of 0 to 1 with 0 implying no agreement on the importance of the ranked barriers, and 1 implying complete agreement on the importance of the ranked barrier with the results being significant if the significance level is less than 0.05 i.e. significant differences within the group(Amasyali and El-Gohary, 2016; Chan et. al., 2003; Kendall and Gibbons, 1990). In this case, the individual parties are private sector public sector, contractors, designer/architect, project management consultants, young professionals, experienced professionals, tenants, and homeowners.

Then, Spearman's rank correlation was used to measure the agreement on the rankings of the barriers between two or more groups i.e. in this case the parties mentioned above (Amasyali and El-Gohary, 2016; Chan et. al., 2003; Chan and Kumaraswamy, 1996). Basically, Spearman's rank correlation measures the correlation on a scale of -1 to +1 with -1 being perfect negative correlation, 0 being no correlation, and +1 being perfect positive correlation in ranking of the barriers. The correlation is considered significant when the level of significance of the Spearman's rank correlation coefficient is less than 0.05 (Amasyali and El-Gohary, 2016).

In the following analyses of the barriers, first, there will be discussion on the key barrier identified within each group of barriers. Second, the report will compare the feedback of private sector, and the public sector. Third, the paper will compare the feedback of contractor, consultants, and the client. At last, there will be a comparison of respondents based on their experience as well. Experienced based comparison will shed light on the opinions of the new entered professionals against the relatively experienced professionals. The other set of discussion will be on the sustainable practices of the respondents, and their awareness of the existing policies in the UAE.

3.3.1 Overall Response

Table 6 is a summary of overall mean scores and rankings based on 34 responses. This section discusses the three high-ranking barriers of each group. First, in the technical groups, the three main barriers identified are: lack of technical expertise of ZEB concepts, lack of previous experience in ZEB projects, and establishing a realistic baseline for ZEB. The overall mean score and ranking based on 34 responses is 3.94 and 10 for each barrier. The lowest mean score and ranking barrier in the technical group is high residual loads, and its impact on the stability grid.

Second, in the economic section, the primary set of barriers identified are: high upfront investment costs, lack of financial incentive to pursue ZEB, longer payback periods, and lack of business of models that consider both short-term and long-term goals of ZEB. The overall mean score, and ranking of these barriers are 4.09, 4.03, and 4.00, and 1,2, and 4 respectively. The mean score of longer payback periods, and lack of business models for short-term and long-term goals are identical i.e. 4.00As per the Table 6, in the economic group of barriers, long term impact of lowering operations and maintenance costs was the low scoring barrier with an overall mean score of 3.62, and a ranking of 24. The mean score of longer payback periods, and lack of business models for short-term and long-term goals are identical i.e. 4.00.

Third, in the social/cultural group of barriers, the respondents believe that lack of knowledge dissemination amongst stakeholders, lack of concept awareness of ZEB, lack of education and training regarding ZEB, and change in occupant behavior to minimize energy consumption are the key barriers in implementing ZEB policies. The overall mean score of these four barriers is 4.00, and the ranking is 4 as well. The low scoring barrier in this group is environmental and health concerns of ZEB during occupancy with an overall mean score of 3.32, and 30 respectively.

Lastly, in the legislative set of barriers, lack of ZEB codes and standards to implement ZEB, lack of long-term assurances by the authority to pursue ZEB, high energy subsidies, and lack of legal framework and laws for implementation of ZEB are the high-scoring barriers. The overall mean scores are 4.03, 3.94, and 3.85 respectively are reflected in Table 6. The overall mean scores of high energy subsidies, and lack of legal framework are identical i.e. 3.85 with the ranking of 17. The ranking of lack of standards to implement ZEB, and lack of long-term assurances by the authorities for pursuing ZEB are 2nd, and 10th respectively. The low scoring barrier in this group is the lack of insurances, and liabilities of ZEB with an overall mean score of 3.62, and the ranking of 24.

Overall, based on 34 responses, the following Table 6 ranks the barriers based on the overall mean scores. Table 6 highlights that the high-ranking barriers are either within the economic, social, or legislative group of barriers. Sequentially, in the economic group of barriers, high upfront investment costs, lack of financial incentives, longer payback periods, and need of business models are the high-ranking barriers with overall mean scores of 4.09, 4.03, and 4.00, and rankings of 1, 2, and 4 respectively. Longer payback periods and need of business models have identical mean scores of 4.00. Then, within the social/cultural group, as mentioned above, disseminating knowledge, concept awareness of ZEB, education and training of ZEB, and change in occupant behavior were the high-ranking barriers with the overall mean scores of 4.00. The mean score of 4.00 is consistent across the social group, and these barriers have attained the 4^{th} position. Lastly, in the legislative group, lack of standards of ZEB, and lack of long-term assurances by the authorities to pursue ZEB are the highly ranked barriers with the overall mean scores of 4.03, and 3.94, and rankings of 2, and 10 respectively.

Table 6: Overall Mean Score & Ranking of Barriers for Implementing ZEB Policies

SN	Group	Barrier Description	Overall Mean Score	**Rank**
1	Technical (T1)	Lack of Technical Expertise of ZEB Concepts	3.94	10
2	Technical (T2)	Lack of previous experience in ZEB projects, and lesson learnt	3.94	10
3	Technical (T3)	several definitions to define ZEB creates confusion	3.47	28
4	Technical (T4)	Establishing realistic baseline for energy consumptions of ZEB	3.94	10
5	Technical (T5)	Differences in Predictive vs Measured Performance of Buildings	3.65	21
6	Technical (T6)	Technical Limitation of ZEB to single-story or multi-story buildings due to the energy consumption requirements of ZEB	3.53	27
7	Technical (T7)	Substantial on-site area to generate renewable energy	3.88	16
8	Technical (T8)	High Residual Loads and its Impact on grid stability	3.44	29
9	Economic (E9)	Effect of high energy subsidies on the ZEB	3.74	19
10	Economic (E10)	Lack of Financial Incentive to Implement ZEB	4.03	2
11	Economic (E11)	High upfront investment costs	4.09	1
12	Economic (E12)	Longer payback periods	4.00	4
13	Economic (E13)	Need of business models that consider short term and long-term goals of ZEB	4.00	4
14	Economic (E14)	Lack of financial gains for the grid operators in maintaining electrical grid	3.65	21
15	Economic (E15)	Economic considerations influencing the decision-making process for investing on ZEB, and energy efficient measures	3.94	10
16	Economic (E16)	long term impact of lowering operations & maintenance costs; no short-term impact	3.62	24
17	Economic (E17)	loss of revenue for vacating building to retrofit a building	3.68	20
18	Social (SC18)	lack of disseminating knowledge of ZEB among stakeholders	4.00	4
19	Social (SC19)	architectural and cultural values of a building limiting the true potential of ZEB technically	3.59	26
20	Social (SC20)	lack of awareness regarding the concept of ZEB	4.00	4
21	Social (SC21)	participation and engagement of stakeholders	3.91	15
22	Social (SC22)	lack of education and training regarding ZEB	4.00	4
23	Social (SC23)	environmental and health concerns when a ZEB building is occupied	3.32	30
24	Social (SC24)	change in occupant behavior to minimize energy consumption, and contribute to the cause of ZEB	4.00	4
25	Legislative (L25)	Lack of standards to implement ZEB	4.03	2
26	Legislative (L26)	subsidies on energy prices (low energy prices)	3.85	17
27	Legislative (L27)	existing policies and standards hinder ZEB goals	3.65	21
28	Legislative (L28)	lack of legal frameworks, and laws for implementation	3.85	17
29	Legislative (L29)	lack of insurances/liability	3.62	24
30	Legislative (L30)	lack of long-term assurances by the authorities for pursuing ZEB	3.94	10
		Number (***N***)	34	
		Kendall's Coefficient of Concordance (***W***)	0.062	
		Level of Significance	0.000	

3.3.2 Comparison of Private Sector and Public Sector

This section compares the responses of the private sector, and the public sector, and the high-ranking barriers of these two groups are compared with the overall ranking of the barriers. Table 7 compares the overall rankings against the rankings of the private, and public sectors.

Upon segregating the responses, 19 responses were collected from the private sector, and 14 responses from the public sector. In the private sector, the high-ranking barriers based on the mean scores are: lack of standards to implement ZEB with a score of 4.26, establishing realistic baseline for energy consumption of ZEB with a score of 4.21, and dissemination of knowledge amongst stakeholders with a score of 4.16. Each of these barriers fall in the category of legislation, technical, and social categories respectively. In contrast, the respondents of the public sector believe that the three predominant barriers to implementing ZEB policies are: longer payback periods (4.13), high upfront investment costs (4.07), lack of financial incentives to pursue ZEB (4.07), and lack of education and training regarding ZEB (4.07).

Based on the results mentioned in Table 7, the private sector's opinions do resonate with the overall responses. For instance, lack of ZEB standards for ZEB achieved 2^{nd}, and 1^{st} position overall, and in the private sector respectively. Whereas, in the public sector, the stated barrier is ranked 15. One can say that public sector is certain that existing standards are enough for integrating ZEB policies. Then, the private sector’s high ranking of establishing realistic benchmark for energy consumption of ZEB is not consistent with either overall, or the public sector’s responses. Another consistency in overall and private sector’s responses are seen for the social barrier of lack of dissemination of knowledge among ZEB stakeholders. This implies that knowledge sharing is a concern, and stakeholders are not well-informed about the ZEB. This barrier is ranked 9th by the public sector. The overall and private sector's rankings are 4th and 3rd respectively. In comparing the responses overall, and the private sector, it is fair to say that there is a dearth of standards for implementing ZEB.

Moving on to the responses of the public sector, the feedback is even more consistent with the overall responses. First, longer payback periods obtained 1st and 4th positions when compared between the public sector, and overall set of responses respectively. However, when it comes to high upfront costs, there is a consistency in responses i.e. both private and public sectors believe that high upfront costs deter people to pursue ZEB. The rankings of the private sector, public sector, and the overall responses are 4th, 2nd, and 1st respectively. Another similarity is seen in the responses of lack of financial incentives to implement ZEB i.e. 2nd position in both overall and the public sector. Lastly, this similarity is also seen across the barrier of training and education pertaining to ZEB as well i.e. 2nd ranking is identical for both overall and the public sector.

On analyzing the agreement on responses within each group, Kendall's Coefficient of Concordance (W) values for the rankings of barriers i.e. private and public sectors are 0.078, and 0.091 respectively. The level of significance for the private and the public sectors were 0.044(high significance), and 0.092(low significance) respectively. The results of the private sector imply that the agreement is low, and significant. Therefore, the null hypothesis that respondents' ratings within each group are related to each other is rejected. Whereas, in comparing with the public sector, the value of significance is greater than 0.05 (i.e. low significance) indicating that the agreement is low, and not significant among the respondents of the public sector group. Hence, the null hypothesis that respondents' ratings are related to each other is retained.

Table 7: Comparison of Barriers in the Private & Public Sector

Group	Barrier Description	Overall Mean Score	Rank	Private Mean Score	Rank	Public Mean Score	Rank
T1	Lack of Technical Expertise of ZEB Concepts	3.94	10	4.11	4	3.73	15
T2	Lack of previous experience in ZEB projects, and lesson learnt	3.94	10	4.05	6	3.80	9
T3	several definitions to define ZEB creates confusion	3.47	28	3.42	30	3.53	25
T4	Establishing realistic baseline for energy consumptions of ZEB	3.94	10	4.21	2	3.60	19
T5	Differences in Predictive vs Measured Performance of Buildings	3.65	21	3.79	20	3.47	26
T6	Technical Limitation of ZEB to single-story or multi-story buildings due to the energy consumption requirements of ZEB	3.53	27	3.58	24	3.47	26
T7	Substantial on-site area to generate renewable energy	3.88	16	3.95	16	3.80	9
T8	High Residual Loads and its Impact on grid stability	3.44	29	3.53	27	3.33	29
E9	Effect of high energy subsidies on the ZEB	3.74	19	3.95	16	3.47	26
E10	Lack of Financial Incentive to Implement ZEB	4.03	2	4.00	11	4.07	2
E11	High upfront investment costs	4.09	1	4.11	4	4.07	2
E12	Longer payback periods	4.00	4	3.89	19	4.13	1
E13	Need of business models that consider short term and long-term goals of ZEB	4.00	4	4.00	11	4.00	5
E14	Lack of financial gains for the grid operators in maintaining electrical grid	3.65	21	3.53	27	3.80	9
E15	Economic considerations influencing the decision-making process for investing on ZEB, and energy efficient measures	3.94	10	4.00	11	3.87	8
E16	long term impact of lowering operations & maintenance costs; no short-term impact	3.62	24	3.58	24	3.67	17
E17	loss of revenue for vacating building to retrofit a building	3.68	20	3.74	21	3.60	19
SC18	lack of disseminating knowledge of ZEB among stakeholders	4.00	4	4.16	3	3.80	9
SC19	architectural and cultural values of a building limiting the true potential of ZEB technically	3.59	26	3.58	24	3.60	19
SC20	lack of awareness regarding the concept of ZEB	4.00	4	4.05	6	3.93	7
SC21	participation and engagement of stakeholders	3.91	15	4.00	11	3.80	9
SC22	lack of education and training regarding ZEB	4.00	4	3.95	16	4.07	2
SC23	environmental and health concerns when a ZEB building is occupied	3.32	30	3.53	27	3.07	30
SC24	change in occupant behavior to minimize energy consumption, and contribute to the cause of ZEB	4.00	4	4.00	11	4.00	5
L25	Lack of standards to implement ZEB	4.03	2	4.25	1	3.73	15
L26	subsidies on energy prices (low energy prices)	3.85	17	4.05	6	3.60	19
L27	existing policies and standards hinder ZEB goals	3.65	21	3.63	22	3.67	17
L28	lack of legal frameworks, and laws for implementation	3.85	17	4.05	6	3.60	19
L29	lack of insurances/liability	3.62	24	3.63	22	3.60	19
L30	lack of long-term assurances by the authorities for pursuing ZEB	3.94	10	4.05	6	3.80	9
	Number (***N***)	34		19		15	
	Kendall's Coefficient of Concordance (***W***)	0.062		0.078		0.091	
	Level of Significance	0.000		0.044		0.092	

Then, Spearman rank correlation coefficient (r_s) was computed to analyze the responses and determine correlation between the groups. In this case, the paper analyzes the responses of the public and the private sector. As mentioned in Table 8, the computed (r_s) between the private and the public sector was 0.432, and the level of significance was 0.017. The correlation is considered significant if level of significance is less than 0.05. Based on the computed values, one can say that the correlation between the groups is weak and significant. Therefore, the null hypothesis that the rankings of barriers between the groups have significant agreement is accepted.

Table 8: Spearman Rank Correlation Test between the Private & Public Sector

			Private (n=19)	Public (n=15)
Spearman's rho	Private (n=19)	Correlation Coefficient	1.000	**.432***
		Sig. (2-tailed)		**0.017**
		N	30	30
	Public (n=15)	Correlation Coefficient	**.432***	1.000
		Sig. (2-tailed)	**0.017**	
		N	30	30
*. Correlation is significant at the 0.05 level (2-tailed).				

3.3.3 Comparison of Construction Sectors

In the industry wise comparison as seen in Table 9, the contractor's ranked the following as the main barriers: high upfront costs, longer payback periods, long-term impact of lowering operations & maintenance costs, and dissemination knowledge amongst stakeholders with an overall mean score of 4.40. Moving on to the consultants i.e. designers and architects, the high-ranking barriers are the need of business models that consider long-term and short-term goals of ZEB (with a mean score of 4.50), lack of financial incentives to implement ZEB (4.38), and high upfront costs (4.38).

Table 9: Comparison of Responses Based on Working Industry

Group	Barrier Description	Overall Mean Score	Rank	Contractor Mean Score	Rank	Consultant Mean Score	Rank	PMC Mean Score	Rank
T1	Lack of Technical Expertise of ZEB Concepts	3.94	10	3.80	13	4.13	7	4.10	5
T2	Lack of previous experience in ZEB projects, and lesson learnt	3.94	10	4.00	8	4.25	4	3.90	13
T3	several definitions to define ZEB creates confusion	3.47	28	3.20	25	3.50	28	3.60	24
T4	Establishing realistic baseline for energy consumptions of ZEB	3.94	10	4.20	5	3.88	18	4.20	2
T5	Differences in Predictive vs Measured Performance of Buildings	3.65	21	4.00	8	3.63	26	3.70	20
T6	Technical Limitation of ZEB to single-story or multi-story buildings due to the energy consumption requirements of ZEB	3.53	27	3.40	23	3.75	22	3.50	26
T7	Substantial on-site area to generate renewable energy	3.88	16	3.60	20	4.25	4	4.00	10
T8	High Residual Loads and its Impact on grid stability	3.44	29	3.60	20	3.88	18	3.40	29
E9	Effect of high energy subsidies on the ZEB	3.74	19	3.60	20	4.00	10	3.60	24
E10	Lack of Financial Incentive to Implement ZEB	4.03	2	3.40	23	4.38	2	4.10	5
E11	High upfront investment costs	4.09	1	4.40	1	4.38	2	4.20	2
E12	Longer payback periods	4.00	4	4.40	1	4.13	7	3.80	18
E13	Need of business models that consider short term and long-term goals of ZEB	4.00	4	3.80	13	4.50	1	3.90	13
E14	Lack of financial gains for the grid operators in maintaining electrical grid	3.65	21	3.80	13	3.63	26	3.50	26
E15	Economic considerations influencing the decision-making process for investing on ZEB, and energy efficient measures	3.94	10	4.00	8	4.00	10	4.00	10
E16	long term impact of lowering operations & maintenance costs; no short-term impact	3.62	24	4.40	1	3.25	30	3.70	20
E17	loss of revenue for vacating building to retrofit a building	3.68	20	3.80	13	3.75	22	3.70	20
SC18	lack of disseminating knowledge of ZEB among stakeholders	4.00	4	4.40	1	4.00	10	4.10	5
SC19	architectural and cultural values of a building limiting the true potential of ZEB technically	3.59	26	4.20	5	3.75	22	3.20	30
SC20	lack of awareness regarding the concept of ZEB	4.00	4	3.80	13	4.25	4	4.00	10
SC21	participation and engagement of stakeholders	3.91	15	3.20	25	3.88	18	4.20	2
SC22	lack of education and training regarding ZEB	4.00	4	3.80	13	4.00	10	4.10	5
SC23	environmental and health concerns when a ZEB building is occupied	3.32	30	3.20	25	3.38	29	3.70	20
SC24	change in occupant behavior to minimize energy consumption, and contribute to the cause of ZEB	4.00	4	4.20	5	3.75	22	4.10	5
L25	Lack of standards to implement ZEB	4.03	2	4.00	8	4.00	10	4.30	1
L26	subsidies on energy prices (low energy prices)	3.85	17	4.00	8	4.13	7	3.90	13
L27	existing policies and standards hinder ZEB goals	3.65	21	2.80	29	3.88	18	3.80	18
L28	lack of legal frameworks, and laws for implementation	3.85	17	3.20	25	4.00	10	3.90	13
L29	lack of insurances/liability	3.62	24	2.80	29	4.00	10	3.50	26
L30	lack of long-term assurances by the authorities for pursuing ZEB	3.94	10	3.80	13	4.00	10	3.90	13
	Number of Responses (***N***)	34		5		8		10	
	Kendall's Coefficient of Concordance (***W***)	0.062		0.214		0.135		0.106	
	Level of Significance	-		0.363		0.353		0.373	

Then, the project management consultants (PMC) viewed the lack of standards to implement ZEB, high upfront investment costs, participation & engagement of stakeholders, and establishing realistic energy consumption baseline for ZEB as the predominant barriers for ZEB policies. Lack of standards to implement ZEB achieved an overall mean score of 4.30, and the remaining barriers scored 4.20 each. Overall the breakdown of the responses is as follows: 5 respondents work in a contracting firm, 8 respondents work as a consultant i.e. designer or architect, and 10 respondents work as project managers.

In comparing the scores, it is observed that only contractors, and project management consultants view realistic energy consumption models as a key technical barrier to ZEB policies. This means that from a designing perspective, creating realistic energy building models may not be a concern. However, contractors and project managements consultants consider this a barrier due to the geographic location, corresponding high energy requirements of the buildings especially during the summer period when temperature increases drastically, and lack of exposure to such projects in this region. This barrier was also positioned at 2 in the private sector, which does indicate that performance of ZEB in the region is a concern. In fact, contractors have considered the operations and maintenance of ZEB for this very reason.

Moving onto financial incentives, the financial incentives are associated with the high upfront costs of the buildings. The designers, and project management consultants are certain that financial incentives are necessary for implementing ZEB. This is because both the parties are engaged by the developers, or client to fulfill their requirements. Most often, the requirement is to construct a project with least costs. Hence, and if the client is not keen on pursuing on ZEB project due to high upfront costs, then, subsequently, designers, and project managements consultants will comply with the needs of the client. On the other hand, contractors construct a project as per the specifications, and quotes accordingly, therefore, contractors do not consider financial investments costs as a barrier. On the other hand, all the sectors are certain that high upfront costs often deter them to pursue ZEB projects.

Next, only designers believe that effective business models are not in place that considers long-term, and short-term goals of ZEB. This is again linked with the goals, and decision-making process of the clients which are often dictated by the financial terms. But contractors and project management consultants do not view this a barrier. Then, there is also a consensus regarding the dissemination of knowledge regarding the ZEB. The project stakeholders, and their understanding of ZEB is crucial as it assists in achieving in common goals. For this reason, project management consultants also consider the participation of project stakeholders as a barrier. As contractors do not participate in the design phase, and the contractors are engaged based on cost evaluations. This method completely overlooks the participation of contractors, and the client is relying on the feedback of the designer for decisions. In the case of UAE this is vital, as ZEB principles are not in practice, the designers can continue to design on existing technical competencies.

At last, all the sectors have also given high scores to lack of standards to ZEB i.e. an overall of mean score greater than 4. This implies that current building codes are devoid of ZEB policies, and there is a need of enacting policies that primarily focus on ZEB. In the private and public sector comparison of barriers, the private sector has given a score to this barrier, whereas, the public sector did not give a high score to this barrier.

Kendall's Coefficient of Concordance W is used to measure the level of agreement within each group i.e. contractors, consultants, and PMC. As highlighted in Table 9, the W values are 0.214 for the contractors, 0.135 for the consultants, and 0.106 for the PMC; whereas, the significance values are 0.363, 0.353, and 0.373 respectively. For the contractors, the level of agreement is low and not significant, therefore, the null hypothesis that respondents' ratings are related to each other is retained. As far as the responses of the consultants are concerned, the measure of agreement is low and not significant as well, hence, the null hypothesis that respondents' ratings are related to each other is retained. Similarly, for the PMC, the level of agreement is even lower and not significant, therefore, the null hypothesis that respondents' ratings are related to each other is retained.

In addition to this, Spearman rank correlation coefficient (r_s) was computed to analyze the responses and determine correlation between the groups i.e. contractors, consultants, and PMC. The following table summarizes the computations of r_s.

Table 10: Spearman Rank Correlation Test between the Contractor Consultant & PMC

			Contractor n=5	Consultant n=8	PMC n=10
Spearman's rho	Contractor n=5	Correlation Coefficient	1.000	0.098	0.290
		Sig. (2-tailed)		0.606	0.120
		N	30	30	30
	Consultant n=8	Correlation Coefficient	0.098	1.000	.493**
		Sig. (2-tailed)	0.606		0.006
		N	30	30	30
	PMC n=10	Correlation Coefficient	0.290	.493**	1.000
		Sig. (2-tailed)	0.120	0.006	
		N	30	30	30
**. Correlation is significant at the 0.01 level (2-tailed).					

The r_s between the contractor and consultant is 0.098, and the level of significance is 0.606; the r_s between the contractor and PMC is 0.290, and the level of significance is 0.120. For these results, one can say that the positive correlation is weak and not significant (greater than 0.01 in this case). As a result, the null hypothesis that the rankings of barriers between the groups (contractor-consultant, and contractor-PMC) have significant agreement is rejected.

A contrasting result is seen between the consultant and the PMC. The computed r_S is 0.493, and the level of significance is 0.006. As mentioned in Table 10, the correlation is significant when the level of significance is less than 0.01. Based on the computations, the positive correlation is strong, and significant. Hence, the null hypothesis that the rankings of barriers between the groups (consultant and PMC) have significant agreement is accepted.

3.3.4 Comparison of Years of Experience

This sector compares the result based on the years to experience. 19 respondents are young professionals i.e. less than 10 years of experience, and 15 respondents are experienced professionals i.e. greater than 10 years of experience. Year wise comparison is to understand how the newly entered workforce opinions fare against the professionals who are practicing for a relatively longer period. More importantly, the understanding of ZEB concept. From professionals with greater than 10 years of experience, lack of awareness of the ZEB concept, education and training regarding ZEB, dissemination knowledge of ZEB among stakeholders, and lack of technical expertise regarding ZEB concepts are the predominant barriers for incorporating ZEB policies. The overall mean of lack of awareness of ZEB concepts, and the stated barriers are 4.53, and 4.33 respectively.

Moving on to the responses of young professionals, the primary barriers are: longer payback periods with an overall mean score of 4.05, higher upfront costs, and need of business models that consider long-term, and short-term goals of ZEB with each obtaining a score of 4.00. The following table compares the overall scores against the years of experiences.

Table 11 compares between the overall mean scores and ranks, and the mean scores and ranks of the young and experienced professionals. In Table 11, the difference of opinion is evident between the young professionals, and the experienced professionals. In fact, the coherency between the young professionals, and the overall responses is evident as well.

Table 11: Comparison of Responses Based on Years on Experience

Group	Barrier Description	Overall Mean Score	Rank	<10 years of experience	Rank	>10 years of experience	Rank
T1	Lack of Technical Expertise of ZEB Concepts	3.94	10	3.63	19	4.33	2
T2	Lack of previous experience in ZEB projects, and lesson learnt	3.94	10	3.68	16	4.27	5
T3	several definitions to define ZEB creates confusion	3.47	28	3.42	28	3.53	27
T4	Establishing realistic baseline for energy consumptions of ZEB	3.94	10	3.95	4	3.93	16
T5	Differences in Predictive vs Measured Performance of Buildings	3.65	21	3.53	25	3.80	18
T6	Technical Limitation of ZEB to single-story or multi-story buildings due to the energy consumption requirements of ZEB	3.53	27	3.58	23	3.47	29
T7	Substantial on-site area to generate renewable energy	3.88	16	3.79	10	4.00	12
T8	High Residual Loads and its Impact on grid stability	3.44	29	3.42	28	3.47	29
E9	Effect of high energy subsidies on the ZEB	3.74	19	3.79	10	3.67	21
E10	Lack of Financial Incentive to Implement ZEB	4.03	2	3.84	9	4.27	5
E11	High upfront investment costs	4.09	1	4.00	2	4.20	9
E12	Longer payback periods	4.00	4	4.05	1	3.93	16
E13	Need of business models that consider short term and long-term goals of ZEB	4.00	4	4.00	2	4.00	12
E14	Lack of financial gains for the grid operators in maintaining electrical grid	3.65	21	3.68	16	3.60	23
E15	Economic considerations influencing the decision-making process for investing on ZEB, and energy efficient measures	3.94	10	3.89	5	4.00	12
E16	long term impact of lowering operations & maintenance costs; no short-term impact	3.62	24	3.63	19	3.60	23
E17	loss of revenue for vacating building to retrofit a building	3.68	20	3.74	13	3.60	23
SC18	lack of disseminating knowledge of ZEB among stakeholders	4.00	4	3.74	13	4.33	2
SC19	architectural and cultural values of a building limiting the true potential of ZEB technically	3.59	26	3.53	25	3.67	21
SC20	lack of awareness regarding the concept of ZEB	4.00	4	3.58	23	4.53	1
SC21	participation and engagement of stakeholders	3.91	15	3.63	19	4.27	5
SC22	lack of education and training regarding ZEB	4.00	4	3.74	13	4.33	2
SC23	environmental and health concerns when a ZEB building is occupied	3.32	30	3.16	30	3.53	27
SC24	change in occupant behavior to minimize energy consumption, and contribute to the cause of ZEB	4.00	4	3.79	10	4.27	5
L25	Lack of standards to implement ZEB	4.03	2	3.89	5	4.20	9
L26	subsidies on energy prices (low energy prices)	3.85	17	3.89	5	3.80	18
L27	existing policies and standards hinder ZEB goals	3.65	21	3.53	25	3.80	18
L28	lack of legal frameworks, and laws for implementation	3.85	17	3.68	16	4.07	11
L29	lack of insurances/liability	3.62	24	3.63	19	3.60	23
L30	lack of long-term assurances by the authorities for pursuing ZEB	3.94	10	3.89	5	4.00	12
	Number (***N***)	34		19		15	
	Kendall's Coefficient of Concordance (***W***)	0.062		0.063		0.126	
	Level of Significance	0.000		0.211		0.003	

Furthermore, the young professionals consider the economic factors as the primary reason to hinder the implementation of ZEB policies. In fact, the young professionals have also highlighted the need of business models that caters long-term, and short-term goals of ZEB. This coincides with the responses of the designers who also believe that current business models do not support the goal of ZEB. In addition to business models, the young professionals believe the high upfront costs deter the implementation of ZEB. This is consistent with the responses of the public sector, and contractors, consultants, and PMC.

Moving onto the responses of the experienced professionals, the responses imply that the experienced professionals are not aware of the ZEB concept, and there is insignificant technical experience pertaining to ZEB concepts. However, the response to lack of dissemination of knowledge among stakeholder is consistent with the responses of the private sector, the construction and project management consultants' industry. This does explain that majority of the project stakeholders do not acquaint themselves with the concept of ZEB effectively. Furthermore, the response of lack of education and training regarding the ZEB concepts is coherent with the response of public sector who consider this as one of the main barriers. A final remark, the responses of the experienced professionals are in tandem with the overall scores of responses.

On analyzing the responses within each group, Kendall's Coefficient of Concordance (W) values for the rankings of barriers i.e. young and experiences professionals are 0.063, and 0.126 with significance level of 0.211, and 0.03 respectively. On the responses of the young professionals (<10 years of experience), the level of agreement is low and not significant. So, the null hypothesis that respondents' ratings are related to each other is retained. On the contrary, for the experienced professionals, the level of agreement is low with high level of significance (<0.05). Therefore, the null hypothesis that respondents' ratings are related to each other is rejected.

Then, Spearman rank correlation coefficient (r_s) was computed to analyze the responses and determine correlation between the groups of young and experienced professionals. Table 12 highlights the r_s computed using the SPSS package.

Table 12: Spearman Rank Correlation Test between the Young & Experienced Professionals

			<10 years of experience n=19	>10 years of experience n=15
Spearman's rho	<10 years of experience n=19	Correlation Coefficient	1.000	.387*
		Sig. (2-tailed)		0.035
		N	30	30
	>10 years of experience n=15	Correlation Coefficient	.387*	1.000
		Sig. (2-tailed)	0.035	
		N	30	30
*. Correlation is significant at the 0.05 level (2-tailed).				

The r_s between the young, and experienced professionals is 0.387 with the significance level of 0.035 (<0.05). Based on the results, the positive correlation is weak but significant. Therefore, the null hypothesis that the rankings of barriers between the groups (young and experienced) have significant agreement is accepted.

3.3.5 Comparison on Rental Contracts and Home Owners

In this section, the report compares barriers based on the type of tenancy contracts. This comparison is of utmost importance because the type of tenancy contract exhibits the decision-making process towards ZEB. There are 23 responses who are currently living as tenants in the UAE i.e. rental contract, or do not own a home in UAE. These tenants view a set of legislative, economic, and technical barriers that effect the implementation of ZEB policies. The top three barriers for the tenants are: lack of standards to implement ZEB, establishing realistic energy baseline for energy consumption of ZEB buildings, and high upfront investment costs with overall mean scores of 4.22, 4.13, and 4.09 respectively.

Besides the tenants' responses, there are 11 respondents who own a home in the UAE. For the home owners, lack of education and training regarding ZEB, change in occupant behavior to minimize energy consumption are the highest-ranking barriers with an overall mean score of 4.18 each. This is followed by high upfront investment costs, need of business models that consider long-term and short-term goals of ZEB, and lack of financial gains for the grid operators to main electrical grid with each scoring 4.09.

In Table 13, it is seen that the overall responses are consistent with the responses of the homeowners. However, as a homeowner, two new barriers emerge from the typical set of responses evaluated in the earlier sections i.e. change in the occupant behavior to minimize energy consumption, and lack of financial gains for the electrical operators to maintain electrical grids. This means that one of the barriers is to change the mindset of the tenants, or the homeowners for conserving energy. But there is a debilitating effect of energy subsidies on minimizing the energy consumption. As discussed earlier, it is difficult to achieve ZEB goals if the governments are encouraging energy subsidies (Khondaker et al., 2016; Krarti and Ihm, 2016).

Then, with electrical grids, financial incentives are missing for both operators, and the homeowners to pursue ZEB goals. There are concerns in maintaining electrical grids when electricity is supplied back to the grid, but, grid friendly policies such as FiT have a positive impact within the EU. (Bruggmann and Henze, 2018; Ramirez et. al., 2017). To highlight, as years pass by, programs like Shams Solar Program will further accelerate in policies that reap financial benefits in maintain electrical grids.

Table 13: Comparison of Barriers between Tenants and Homeowners

Group	Barrier Description	Overall Mean Score	Rank	On a Rental Contract (N=23)	Rank	Homeowner (N=11)	Rank
T1	Lack of Technical Expertise of ZEB Concepts	3.94	10	4.04	4	3.73	14
T2	Lack of previous experience in ZEB projects, and lesson learnt	3.94	10	3.96	12	3.91	10
T3	several definitions to define ZEB creates confusion	3.47	28	3.43	27	3.55	22
T4	Establishing realistic baseline for energy consumptions of ZEB	3.94	10	4.13	2	3.55	22
T5	Differences in Predictive vs Measured Performance of Buildings	3.65	21	3.74	20	3.45	26
T6	Technical Limitation of ZEB to single-story or multi-story buildings due to the energy consumption requirements of ZEB	3.53	27	3.48	25	3.64	18
T7	Substantial on-site area to generate renewable energy	3.88	16	3.91	16	3.82	12
T8	High Residual Loads and its Impact on grid stability	3.44	29	3.43	27	3.45	26
E9	Effect of high energy subsidies on the ZEB	3.74	19	3.83	19	3.55	22
E10	Lack of Financial Incentive to Implement ZEB	4.03	2	4.04	4	4.00	6
E11	High upfront investment costs	4.09	1	4.09	3	4.09	3
E12	Longer payback periods	4.00	4	4.00	8	4.00	6
E13	Need of business models that consider short term and long-term goals of ZEB	4.00	4	3.96	12	4.09	3
E14	Lack of financial gains for the grid operators in maintaining electrical grid	3.65	21	3.43	27	4.09	3
E15	Economic considerations influencing the decision-making process for investing on ZEB, and energy efficient measures	3.94	10	3.96	12	3.91	10
E16	long term impact of lowering operations & maintenance costs; no short-term impact	3.62	24	3.57	24	3.73	14
E17	loss of revenue for vacating building to retrofit a building	3.68	20	3.74	20	3.55	22
SC18	lack of disseminating knowledge of ZEB among stakeholders	4.00	4	4.00	8	4.00	6
SC19	architectural and cultural values of a building limiting the true potential of ZEB technically	3.59	26	3.48	25	3.82	12
SC20	lack of awareness regarding the concept of ZEB	4.00	4	4.00	8	4.00	6
SC21	participation and engagement of stakeholders	3.91	15	4.00	8	3.73	14
SC22	lack of education and training regarding ZEB	4.00	4	3.91	16	4.18	1
SC23	environmental and health concerns when a ZEB building is occupied	3.32	30	3.43	27	3.09	30
SC24	change in occupant behavior to minimize energy consumption, and contribute to the cause of ZEB	4.00	4	3.91	16	4.18	1
L25	Lack of standards to implement ZEB	4.03	2	4.22	1	3.64	18
L26	subsidies on energy prices (low energy prices)	3.85	17	4.04	4	3.45	26
L27	existing policies and standards hinder ZEB goals	3.65	21	3.65	23	3.64	18
L28	lack of legal frameworks, and laws for implementation	3.85	17	3.96	12	3.64	18
L29	lack of insurances/liability	3.62	24	3.70	22	3.45	26
L30	lack of long-term assurances by the authorities for pursuing ZEB	3.94	10	4.04	4	3.73	14
	Number (***N***)	34		23		11	
	Kendall's Coefficient of Concordance (***W***)	0.062		0.087		0.097	
	Level of Significance	0.000		0.001		0.363	

As seen in earlier analyses, (W) is computed to discuss the level of agreement and level of significance within the groups of rental contracts, and homeowners. As stated in Table 13, the values of W, and level of significance of the professionals under a rental contract are 0.087, and 0.001 respectively. On the other hand, the W, and level of significance of the homeowners are 0.097, and 0.363. For the rental contract, the value of W is closer to 0 which means that the level of agreement is weak, but the differences are significant. Thus, the null hypothesis that respondents' ratings are related to each other is rejected.

Then, for the homeowners, this is not the case with the responses of the homeowners to a certain extent. The W is closer to zero implying no agreement within the respondents. However, the level of significance is greater than 0.05, and this means that there are no significant differences in the group. So, the level of agreement is low with not significant, and as a result, the null hypothesis that respondents' ratings are related to each other is retained.

Like the earlier sections, Spearman rank correlation coefficient (r_s) was computed to analyze the responses and determine correlation between the groups of rental contracts and homeowners. The following table.is the computation of the r_s, and the level of significance using the SPSS package.

Table 14: Spearman Rank Correlation Test between the Rental Contracts and Homeowners

			Rental n=23	Homeowner n=11
Spearman's rho	Rental n=23	Correlation Coefficient	1.000	0.277
		Sig. (2-tailed)		0.138
		N	30	30
	Homeowner n=11	Correlation Coefficient	0.277	1.000
		Sig. (2-tailed)	0.138	
		N	30	30

As per the Table 14, the r_s between the rental contracts, and the homeowners is 0.277, and the level of significance is 0.138. Based on the results, it is fair to state that the positive correlation is weak, and not significant. Therefore, the null hypothesis that the rankings of barriers between the groups (rental contracts and homeowners) have significant agreement is rejected.

3.3.6 Challenges to ZEB

In addition to the identification of barriers to implementing ZEB policies, respondents were also asked about the challenges that the policy makers may confront during the execution phase. Figure 11 illustrates the summary of the results obtained.

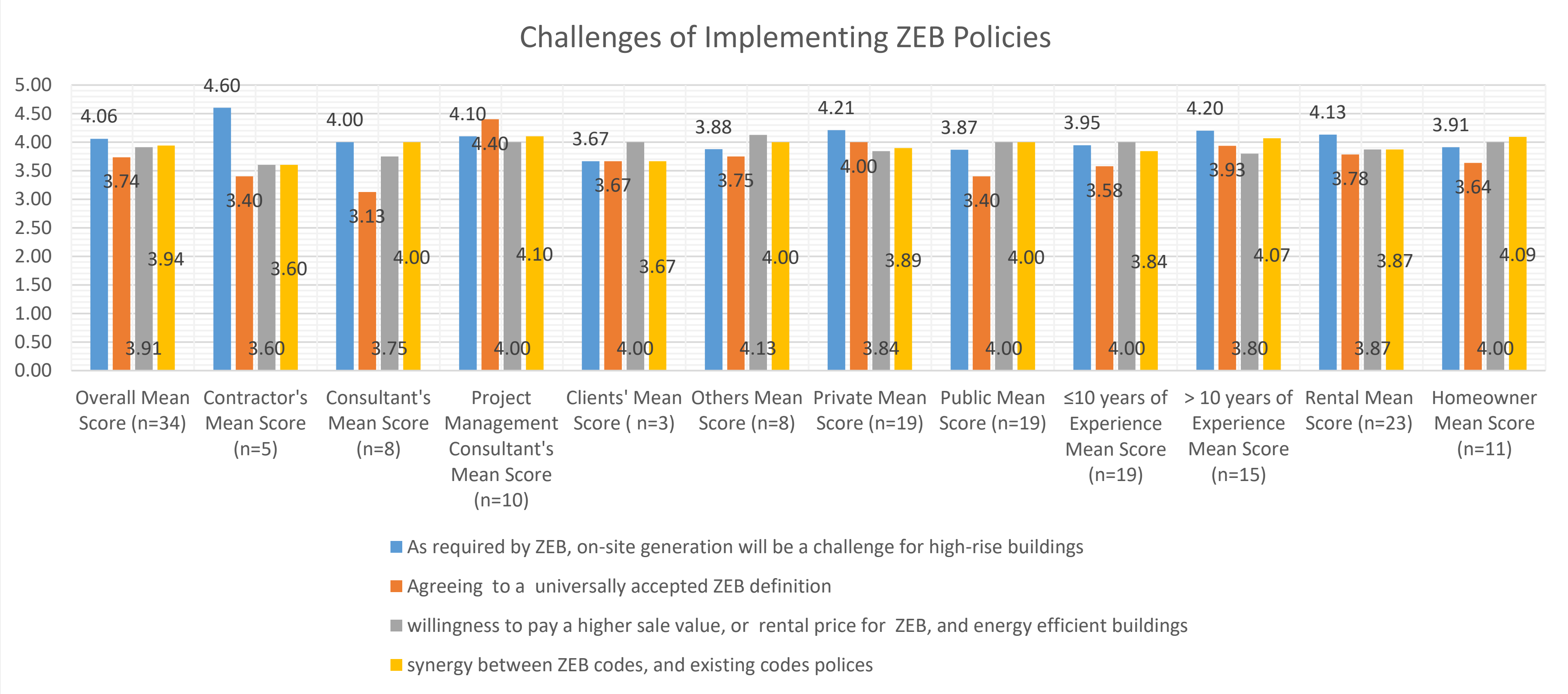

Figure 11: Challenges of Implementing ZEB Policies

In the Figure 11, the y-axis represents the mean scores, and the x-axis represents the sector under evaluation. The overall responses highlight that generation from renewable energy resources will be the primary challenge for high-rise buildings. One interesting observation form the results is the response of the tenants, and the homeowners towards the higher rental, or sale price of ZEB and energy efficient buildings. Surprisingly, both tenants and homeowners consider costs as the second most challenge aspect of implementing ZEB after on-site generation for high-rise buildings, and synergy between ZEB and existing building codes respectively. Moreover, interestingly, the homeowner, and the other groups have raised concerns regarding the higher rental prices, and sale prices of the ZEB, and energy efficient buildings. One of the main reasons is the demographics of the UAE. Expatriates represent a greater share of the population and investing high amounts on ZEB can be a concern. Unless, investment subsidies, or other opportunities are created for encouraging ZEB, this will remain a challenge along with synergy between ZEB and existing codes, and more importantly, enough on-site generation for meeting energy requirements of high-rise buildings.

Chapter 4 - Discussions

From the results, and analyses, it is safe to draw the following conclusions. From the technical group of barriers, the most important to implementing ZEB policies is establishing realistic baseline energy consumptions for ZEB. In the economic group of barriers, lack of financial incentives, high upfront invest costs, longer payback periods, and need of business models for pursuing are crucial to ZEB policies. For example, Wells et. al. has stated that a business model that proves the feasibility of ZEB in Australia is still non-existent (Wells et. al., 2018).

Next, in the social/cultural set of barriers, dissemination of ZEB knowledge among stakeholders, and lack of education and training regarding ZEB continue to hinder ZEB policies. Last but not the least, from legislative perspective, only lack of standards to implement ZEB features the list of barriers. Keeping the above stated group of barriers into consideration, the legal framework can preferably work around these barriers, or else the framework will entail risks to smooth transition towards ZEB.

4.1 Discussion on the Overall Responses

This section explores the reasoning behind the feedback of the respondents based on the comparison of responses in the analyses section. The working sector, years of experience, and type of residential contract shed light on the behavior of the respondents to a certain extent. Before delving into the discussions, the paper discusses the overall responses briefly.

In the economic group of barriers, for transition to towards ZEB, government needs to incentivize ZEB projects as majority of the respondents are on rental contracts, and the longer duration to breakeven discourages the end-user to invest in ZEB projects. Also, the government along with the industry can conduct workshops, and collaborate to establish business models that consider both financial gains, and reduction in energy emissions for short-term and long-term goals respectively. To tackle high upfront costs, governments can encourage use of locally sourced materials that can significantly reduce emissions and costs of goods that arise due to transportation of goods from international markets. Simultaneously, this can potentially reduce the embodied energy of the materials.

Moving on to the next category of barriers i.e. social, the barriers identified in the social group of barriers are coherent with the ones identified in the technical section i.e. lack technical understanding of ZEB, and lack of previous experience pertaining to ZEB. This is because education and training, and concept awareness are correlated with the technical expertise, and exposure to ZEB projects. By receiving education and training, the industry can bring the knowledge into practice. Hence, conducting workshops and engaging stakeholders for raising awareness of ZEB concepts is equally important. In addition to this, even though respondents believe that bringing a change in the occupant behavior can potentially hinder the implication ZEB policies. It comes as a surprise that respondents do not consider high energy subsidies on energy as a barrier to implementing ZEB policies. High energy subsidies are positioned at 19 with an overall mean score of 3.74. This is simply because high energy subsidies are correlated with the energy consumption. One way to tackle resistance in occupant behavior is by eliminating or at least minimizing energy subsidies. ZEB is not viable if high energy subsidies are in practice. Similar concerns were discussed by Krarti and Ihm while evaluating ZEB in the MENA region (Krarti and Ihm, 2016).

Next in discussion is the legislation group of barriers, currently, the building industry in UAE is devoid of ZEB codes and standards, and legal framework to practice ZEB concept. The responses reflect the current practices in the UAE. Also, as discussed above, energy subsides are predominant in the region. Therefore, there is a dire need of policies that sets a timeline and ensures transition towards ZEB. These codes and policies can simultaneously coexist, and complement the existing renewable energy, and energy efficiency policies of UAE. For instance, regulators can tend to work on providing a framework for ZEB in parallel with several goals such as UAE Energy Strategy 2050, and Shams Solar Program. In this manner, numerous targets such as reduction in emissions, generation of energy from renewable resources, and reduction in overall energy consumption of the buildings.

Typically, prior experience, and lessons learnt from a construction project are essential for future projects in averting situations that impact the construction projects in terms of cost, schedule, and even quality. In the case of limited exposure to ZEB, developers, clients, and even construction professionals are not pursuing ZEB projects for the following three reasons. One as a developer or project financer, cost overruns are often a concern in terms of finances as this effect the cashflows, and at times the project timeline. So, as a developer, cost uncertainty and the prior exposure of the project stakeholders in the ZEB projects can deter them in pursuing such projects.

Second, the experience of construction professional does play a vital role in ZEB projects. The subject of green buildings, and ZEB are relatively new in this region. So, experienced professionals with significant years of experience do not have the exposure to ZEB projects, or in fact, the core principles of green buildings were not introduced during their formal education. Hence, the designers, or contractors will fall back to traditional construction practices that were taught and practiced during their years of formal education. This is primarily because of their thorough understanding, and level of comfort with the well-established conventional construction methods.

Third and last, in the UAE, the role of the consultants (designers/architects) is crucial because the project developers often consult them in the decision-making process. So, the designers are often under the radar if their recommendations do not meet the expectations of the developers i.e. in case of undesirable results. For a designer, to have the trust of the client/developer is important as well. So, the designers tend to give recommendations, and solutions that are reliable, previously practiced in earlier projects, and at the same time, entails minimum risk. Thus, adapting a novel idea such as the ZEB face barriers in implementation.

4.1.1 Discussion on Responses of Private & Public Sectors

In addition to the above comparison, it is equally important to understand the reasoning behind both public and private sectors' responses. Generally, the public sector has several important roles but from a construction perspective ensuring compliance with the established codes and standards and honing the skills of the private sector whenever necessary. From the perspective of private sector, the primary responsibility of the private sector is to abide by the policies enacted by the government, and construct buildings in accordance with the codes and standards enacted by the government. To highlight, at the time of survey, none of the respondents in the private sector were holding the position of the client. The respondents who highlighted themselves a part of the private sector were working either as designers, contractors, project management consultants, or in a non-profitable organization.

Longer payback periods, high upfront investment costs, lack of financial incentive to implement ZEB, and lack of education and training regarding ZEB are the high-ranking barriers by the respondents of the public sector. The first three barriers are associated with the economic aspect of the ZEB. From the rankings, it is seen that the public sector does acknowledge the fact that longer payback periods, and high upfront costs discourage people, and developers in investing at ZEB. There are a couple of economic concerns for not implementing ZEB policies. First is the operations and maintenance costs of ZEB. As ZEB relies on renewable resources for energy consumption, the cost to maintain and operate renewable resources further prolongs the payback period. As the Government of UAE has introduced several strategies, financial incentives and projects pertaining to the RE, there will a massive reduction in costs of operating and maintaining renewable energy resources, thus, increasing the likelihood of a decrease in the payback period in the foreseeable future.

Second is the sourcing of energy efficient and environmentally friendly materials that increases the cost drastically. In majority of the cases, these materials are sourced from the international market that leads to high construction costs, and thus, increasing the payback periods. One must not forget, sourcing a material from an international market is correlated with the high embodied energy as well. As mentioned in the literature, there are discussions on the need to consider, or ignore the embodied energy in the ZEB. Back to high upfront costs and longer payback periods in the UAE, the construction related decisions are heavily reliant on the economic factors, and financial incentives can play a significant role in encouraging ZEB projects. Currently, there are no legislation, or financial incentive specifically for ZEB projects. In UAE, like any other market, the construction project is pursued for two reasons mainly: occupying the property after completion, or for leasing. So, for maximizing rate on investment, the investor will lay emphasis on reducing payback period, and minimizing upfront construction costs. Due to these reasons, financial incentives such as lower interest rates, public-private partnerships, and benefits to early adopters are essential to success of ZEB projects.

Another high-ranking barrier is the lack of education and training regarding the concepts of ZEB. This is extremely crucial to implementing ZEB policies because the socioeconomic benefits are not well known to the people of this region. Therefore, the education and training are necessary for two reasons: increasing the technical capabilities of the public and private professionals in the construction industry and highlighting the social impact of ZEB.

First, by honing the skillset of professionals, the private sector will have an exposure to the principles of ZEB, and simultaneously, increase the likelihood of promoting, and getting involved in ZEB projects. Typically, the public sector is responsible for enforcing codes and standards, and as a follow-up ensure the private sector complies to these standards. Typically, in the UAE, for a newly introduced legislation, code, or even standards, the government ensures there is ample time for the private sector to acquaint themselves with the newly introduced requirement. Then, if necessary, the public sector facilitates trainings, education, and time to the private sector which leads to the smooth transition towards new buildings codes, and standards. However, when it comes to ZEB, the public sector believes that not enough is being done when it comes to improving the skillset of the professionals. Of course, this is primarily because the Government of UAE is yet to formally introduce the ZEB regulations.

Second, from a social perspective, the construction industry will understand the true potential of ZEB in terms of minimizing CO_2 emissions, and healthy living with the help of these trainings. Also, through these trainings, one important statistic worth highlighting is the constant featuring of the UAE in the list CO_2 emissions/capita (IEA, 2018). This will serve as a reminder to the construction industry that abiding by the existing rules and regulation are not enough to meet the targets of the Paris Agreement, and the Government of UAE; there is a need to focus on effective construction methods and techniques. It is an uphill task to expect impressive results in reducing carbon emissions in the building industry without proper education and training pertaining to ZEB. In addition to this, one cannot overlook the role of private sector in driving the market of ZEB by recommending ZEB to the clients. Overall, the trainings and educating the private sector are critical for the ZEB in the UAE.

Moving on, the private sector sees the lack of standards, lack of dissemination of knowledge of ZEB among stakeholders, and establishing realistic energy consumption baseline of ZEB as the barriers to implementing ZEB policies in the UAE. There is a relationship between the lack of standards to implement ZEB and lack of dissemination of knowledge of ZEB among project stakeholders. As discussed above, there are no standards, building codes, and legislations promoting or encouraging ZEB. So, it is highly unlikely that the private sector will pursue ZEB projects that is far more stringent than the existing codes, and regulations pertaining to the mandatory green building requirements. For the sake of compliance, the private sector will abide with the existing minimum set of existing rules and standards. There are several factors for such routine practices: the ease in complying with the minimum existing codes and standards, maintaining the trust of the client, and the uncertainty in pursuing new concepts such as ZEB.

First, abiding with the minimum set of standards is closely associate with the human behavior. Typically, humans will fall back on routine practices because applying lessons learnt from previous project entails minimum risks in the new projects. Also, it is always easier to reapply the techniques practiced in earlier projects.

Second, for the private sector, it is equally important to maintain the client relationship because of trust, and future opportunities with the same client. Client's satisfaction with the performance of the designers, contractors, or subconsultants paves way for future collaborations as well.

Third and last, due to the limited exposure to ZEB projects in the UAE, the private sector is not thorough with the principles and practices of ZEB. As a result, the private sector including but not limited to designers, contractors, and even project management consultants do not discuss ZEB with the client during the initial stages of the project. This is a major reason for prevalence of traditional construction methods and techniques in the industry. In fact, it is due to the lack of understanding and dissemination of knowledge pertaining to ZEB, the private sector considers ZEB as a potential risk in the client-consultant/contractor relationship that may diminish the chances of working with the client in the future projects. Consequently, the private sector tends to follow well-established codes and regulations that entail minimum risks and rely on those techniques that are practiced over the years. Therefore, the role of the private sector is vital in disseminating knowledge among the stakeholders such as the client or project developers.

On the other hand, the public sector believes there are enough standards to implement ZEB principles through localized (city based) green building regulations, DIES 2030, and UAE Clean Energy Strategy 2050. To highlight, lack of standard to implement ZEB was ranked 15 by the public sector. This low scoring can be attributed by relating the existing policies such as the DIES 2030, DIES 2050, and UAE Clean Energy Strategy 2050 with the principles of ZEB.

Lastly, the private sector highly ranks establishing a realistic benchmark for integrating ZEB as a barrier. This is primarily due to reasons such as the prevailing subsidies on the energy consumption, and the geographic location of UAE. First, it is seen in the literature that energy subsidies in the GCC region prolongs the payback period of a ZEB drastically (Krarti and Ihm, 2016). Initial steps in assimilating ZEB is to at least marginalize energy subsidies to encourage ZEB projects. Otherwise, occupants will continue to prefer conventional buildings.

Second, the public and private sectors need to have a mutual consensus prior to establishing the benchmark on the energy consumption, or the private sector will struggle to bring the ZEB into reality. This was seen in the case of Sweden where optimistic energy consumption was a barrier for ZEB (Lindkvist et. al., 2014). So, it is essential to conduct several public-private workshops prior to issuance of codes and standards for discussing issues faced during the design phase, and potential issues that may arise during the operations of the ZEB. This ensures active participation of the private sector, and simultaneously, it assists in the active participation of the construction industry. In not doing so, the private sector may continue with the routine practices, and rely on existing green building regulations of the country. To reiterate, in comparison to the green buildings, ZEB is a far more stringent approach to address issues such as energy consumption where use of renewable energy to meet the energy requirements of the building is necessary. One option worth exploring is the combination of off-site RE generation with on-site re generation for balancing the needs, and requirements of the buildings in the UAE.

Third and last, in establishing an appropriate benchmark for the energy consumption of ZEB, ONE must not ignore the geographic location of the GCC region. GCC is ideally placed for the solar energy, but at the same time, one must heed the exponential rise of energy requirements during the summer period. Therefore, ZEB codes and standards including the benchmarking of energy consumption in a ZEB will require active participation of both private and public sectors to identify the weak links such as defining

ZEB from the perspective of this region, the dire need to minimize CO_2 emissions/capita to improve the global rankings of the UAE, high upfront costs of ZEB, and enhancing the technical capacity in terms of ZEB.

As cost considerations such as cost overruns are predominant in the construction industry, these are correlated with the demographics of the UAE, and the type of home i.e. rental, or homeowner. So, these discussions are in the following sections.

4.1.2 Discussion on Responses of Construction Sectors

This section discusses the responses of the contractor, and designers, and the project management consultants respectively. There are four barriers that are highly ranked by the contractors: high upfront costs, longer payback periods, long-term impact of operations and maintenance costs and no short-term impact, and lack of disseminating knowledge of ZEB among stakeholders. All these barriers were ranked equally. Three of these barriers belong to the economic category, whereas, the remaining one is a social barrier. The reasonings for high ranking of high upfront costs, longer payback periods, and lack of disseminating knowledge of ZEB are already discussed in the above section. One interesting barrier highly ranked by the contractors is the long-term impact of lowering operations and maintenance costs and no short-term impact; in other set of comparisons this is not a highly-ranked barrier. This shed lights on several elements in the post-occupancy phase of the building. First, the overall cost benefits by minimizing operations and maintenance costs benefits are seen over a certain period. There are no immediate financial gains of lowering operations and maintenance costs. This can potentially deter the project developers in purchasing products labeled as energy efficient as there are no immediate returns.

Another, lowering operations and maintenance costs are only beneficial if the investor is the occupant itself. If the project is a mixed-used development with a combination of retail, commercial, or even residential apartments on lease. Then, the developer is not concerned with the overall operations and maintenance costs; the tenants will bear certain portion of the costs of maintenance on an annual basis. However, the developer can promote ZEB by emphasizing on lower operating and maintenance costs to lure potential tenants; this leads to an even higher occupancy. In addition to this, organizations may prefer occupying such properties and even willing to pay a higher premium because several organizations are laying out the framework to become sustainable by minimizing CO_2 emissions, and focusing on RE generation. Back to operations & maintenance costs, the ZEB does lower the operating and maintenance costs, but, the overall positive impact is not immediate, and this derails the implementation of ZEB policies.

Moving on to the responses of the designers, the three high-ranking barriers are need of business that consider long-term and short-term goals of ZEB, lack of financial incentive to implement ZEB, and high upfront investment costs. The latter two are already discussed in the above section. The need of sustainable business model that supports both the long-term and short-term goals is crucial to the implementation of ZEB not only in the UAE, but in the GCC region. This barrier is a combination of economic, and legislative parameters. First, as seen in the European market, the cost of investment in the ZEB varies, but overall, the costs are significantly higher. One of the studies estimates an average investment of between $8400-$15,166 above the building code requirements (Anderson et. al., 2006). Second, the energy subsidies in the GCC region further hamper the case of implementing the ZEB. Third, there are no investment incentives on ZEB although there are incentives for investing in the PVs. Last, the lack of standards to implement practically make it difficult for the designers to bring the practice of ZEB into practice. To reiterate, the clients weigh the cost impact prior to a decision. Unless, a sustainable business model of ZEB that benefits everyone the investor, and the end-users during the occupancy phase, the implementation of ZEB policies will be an uphill task.

Next, the project management consultants'(PMC) highly-rank the following barriers: lack of standards to implement ZEB, establishing realistic baseline for energy consumptions, high upfront investment costs, and participation and engagement of stakeholders. Keeping aside the latter, the other barriers are already discussed in the above section. Usually, designers, project architects, and PMC are involved from the early design stages of the project. At this stage, only the designers and consultants are an integral part of the client discussions, So, the contractor does not have the opportunity in contributing during the early design state. If the project is not a design-build, a contractor only comes into the picture upon completion of the tendering phase i.e. nomination of the lowest responsible bidder. An early engagement of the contractor can play a significant role in identifying major risks that may occur during the construction. At the same time, participation of all the parties will ensure that project requirements are well understood with no compromise on the project goal at a later stage. Encouraging participation can also eliminate the barrier of disseminating knowledge of ZEB among stakeholders.

Also, this sheds light on the fact that the construction industry needs to strike a balance in engaging all the stakeholders. In fact, in this part of the region, it is seen that decisions such as changes in design are often imposed on the contractors without understanding the overall implications and risks of these decisions. For a contractor to maintain healthy relationships with the client, the contractors often commit without acknowledging the risks of these decisions, as a result, the contractor fails to meet the expectations of the client, and this failure strains the relationship between the contractor and the client/owner. This does not come as a surprise as majority of the risks are assigned to the contractor or shared between the owner and the contractor (El-Sayegh, 2008). For all the above reasons, PMC believes that there is a need to strike a balance by actively engaging the project stakeholders, and PMC has a vital role in eliminating this barrier.

4.1.3 Discussion on Responses of Years of Experience

This section compares the results of two groups of people: first, professionals who have accumulated up to 10 years of experience, and second, those experienced professionals who are in the construction industry for more than 10 years. For the latter group of professionals, the high-ranking barriers are lack of awareness regarding the concept of ZEB, lack of education and training regarding ZEB, lack of dissemination of knowledge of ZEB among stakeholders, and lack of technical expertise of ZEB concepts. Whereas, the young professionals highly rank the economic barriers: longer payback periods, high upfront investment costs, and need of business models that consider short-term and long-term goals of ZEB. The economic barriers and the two social barriers i.e. lack of disseminating knowledge of ZEB among stakeholders, and lack of education and training regarding ZEB are discussed in the earlier sections. So, this section will mainly focus on the highly-ranked barriers not discussed in the earlier sections i.e. lacking awareness and technical expertise.

Looking at the feedback, there is a clear distinction between the opinions of the young and experienced professionals. Young professionals believe that economic factors tend to derail the implementation of ZEB policies. On the other hand, the experienced professionals consider social factors as the key barriers to implement ZEB policies. The experienced group of professionals believe that the people are not fully aware of the ZEB concept, and this will hinder the implementation of ZEB policies. This social factor is crucial because both the professionals, the society needs to imbibe the concept of ZEB as well. This is because the collective efforts of the society will experience a surge in low energy consumption of the buildings overall. This low consumption is only possible by practicing principles of ZEB i.e. use of renewable resources for energy consumption, and to a certain use of energy efficient appliances. As a result, the CO_2/capita of the UAE will drop as well.

Another reason is the acquaintance with the concept of ZEB from an educational perspective. The subject of green buildings is relatively new in this region although UAE represents high numbers of green buildings in the region (USGBC, 2018). In fact, the literature has only discussed the subject in detail over the past decade and a half. The ZEB is still a novel idea, and researchers are still exploring the extent of benefits in entirety. Not to forget the prevailing disagreements on the definitions of ZEB. So, to say that experienced professionals with greater than 10 years of experience were not introduced with the concept of ZEB during their period of higher education would not be wrong. Thus, these experienced professionals are not aware of ZEB, and sustainable practices in construction. In parallel, over the years, these professionals did not obtain, or acquire the required technical expertise of ZEB to bring these topics into practice. It does not as a surprise that the experienced professionals have also highly-ranked the lack of education and training regarding the ZEB as this is correlated with the awareness, and technical expertise of ZEB as well.

In addition to this, the reasoning of higher education is backed by the responses of the young professionals who have given low scores to the social and technical group of barriers. The overall rankings of technical expertise, lack of disseminating knowledge of ZEB among stakeholders, awareness, and education and training are 19, and 13 each for the latter three respectively. This indicates that young professionals are familiar to the principles of ZEB. There is a likelihood that introduction, and discussions of ZEB took place during the higher education of these young professionals.

Then, another important factor worth mentioning is the response to change in the construction industry. One such example is the practice of project partnering in the construction industry that encourages collaborative approach to achieve common objective by means of trust, and long-term commitment (Chan et. al., 2003). In such approach, the client, consultants, and the contractors participate in workshops to understand the scope, and objectives. In a conventional construction project, the contractor only appears during the execution phase only. The contractor does not participate in the prior phases of project initiation and design. Back to project partnering, one of the barriers in implementing project partnering was the opposition to adapt such change in the existing culture (Chan et. al., 2003). The prevailing culture conditions are hard to change (Chan et. al., 2003; Lazar, 1997). Similarly, the concept of ZEB may face such identical situations where the construction industry is not receptive on the implementation of ZEB policies. It is often an uphill task to come out of the comfort zone to adapt changes. Therefore, from a holistic point of view, it is equally important to focus on the social and cultural impact to ensure success of ZEB policies.

The technical expertise of ZEB is another barrier highly-ranked by the experienced professionals that does not come as a surprise. By now, the above discussions on the lack of standards for implementing ZEB, and limited exposure of the experienced professionals to the ZEB projects are well established. All of these are correlated with the technical expertise of ZEB. First, by enacting ZEB standards and procedures, the construction industry will have no choice but to bring the principles of ZEB into practice. Another reason for high-ranking of technical expertise is the limited exposure to ZEB. The experienced professionals were not exposed to such concepts in higher education. Subsequently, the professionals relied on the existing methods and techniques to fulfill project requirements.

So, the construction industry did not find the need of honing technical capabilities when it comes to ZEB. As a result, the experienced professionals believe the construction industry is devoid of technical expertise that will significantly impact the implementation of ZEB policies in the UAE.

4.1.4 Discussion on Responses by Rental Contracts & Homeowners

The reasoning behind the responses of both the professionals in a tenancy contract are compared, the homeowners in the UAE are discussed in this section. The high-ranking barriers for the tenants are lack of standards to implement ZEB, establishing realistic baseline for energy consumption of ZEB, and high upfront investment costs respectively. Whereas for the homeowners, the high-ranking barriers are: lack of education and training regarding ZEB, change in occupant behavior to minimize energy consumption to contribute to the cause of ZEB, high upfront investment costs, need of business models to consider long-term and short-term goals of ZEB, and lack of financial gains for the grid operators in maintaining electrical grid.

As per the latest report of UN, as of 2019, the population of UAE is approximately 9.77M, and in 2017, the population was 9.49M (United Nations Statistics Division, 2019c). As per the UN, in 2017, the non-UAE citizens (expatriates or immigrants) are approximately 8.31M i.e. ±88.4% of the entire population (United Nations Statistics Division, 2019a). In the category of expatriates, the South East Asians (Indians: ±38%, Bangladesh & Pakistan: ±9% each) followed by Egyptians at ±10%, and Filipinos at ±6% are the main ethnic groups in the UAE (CIA, n.d.). Over the years, the population numbers experience an increase, or decrease depending on the economic conditions and the job opportunities for both citizens, and expatriates. So, there is a transient element in the population of the UAE.

Moving back to the discussion on the expatriates, there are a couple of reasons behind the expatriates' preference to stay and work in the UAE. First, the expatriates get the opportunity to improve their standard of living. The following table compares the GDP per capita of Egypt, India, Pakistan, Philippines, and UAE for the year 2017 (United Nations Statistics Division, 2019b).

Table 15: Comparison of GDP/capita (United Nations Statistics Division, 2019b)

SN	Country	GDP per capita ($)
1	Egypt	2,023
2	India	1,961
3	Pakistan	1,458
4	Philippines	2,982
5	UAE	39,812

Second, by working in the UAE, the expatriates often support their families back home financially i.e. remittance. As per the Central Bank of UAE, in 2017, total remittances outflows from UAE were AED 164.4B (Central Bank of the U.A.E., 2018). Out of the 164.4B, approximately 57% of these remittances were transmitted from the UAE banks to the following seven countries: 35.3% to India (AED 57.9B), 9.4% to Pakistan (AED 15.2B), 7.1% to Philippines (AED 11.6B), and 5.1% to Egypt (AED 8.4B). Besides the high volume of remittances, there are other factors to account for the expatriates' cost of living i.e. including but limited to transportation, tenancy, and education. These statistics are necessary to this paper because it highlights two important factors: transient nature of the population dependent on economic developments and job opportunities, and the large percentage of expatriates and their high percentage of remittances.

Now, referring to Table 13, the professionals under the rental contracts believe that striking a balance in the energy consumption for benchmarking will be a concern for the implementation. This is because UAE experiences extreme hot and humid conditions during the summer period, and relatively cooler winter periods. Due to this, energy consumption in summer period is higher in comparison to the winter period. So, for the policy-marking, there will be concerns on the necessary measures to establish a realistic energy consumption for benchmarking i.e. either to establish a monthly energy consumption chart, an annual energy consumption, or an average energy consumption based on evaluation of a 1year cycle. Plus, a study has concluded that energy consumption is correlated with the occupant comfort (Shrestha and Kulkarni, 2013). Therefore, to establish a balance between these two contrasting conditions that resolves concerns pertaining to occupant comfort can be a daunting task for defining the energy consumption of ZEB in the UAE. Another barrier highlighted by the professionals under the rental contract is lack of standards to implement ZEB. Being under a tenancy contract, a tenant needs to comply with the requirements of the developer/homeowner. If there no standards and codes to implement ZEB, then, tenants are left with no option but to comply with the prevalent standards. Hence, as discussed in above sections as well, the governing bodies need to implement ZEB codes and standards to commence the process of integration initially.

Lastly, the professionals under tenant contract consider the high upfront investment costs will deter the implementation of ZEB policies. This is primarily due to the transient nature of the population, majority of the population will refrain from investing astronomical amounts in ZEB as factors such as the cost of living, and remittances will influence the decisions of the professionals under a tenancy contract. This is also consistent with the responses of the homeowners who believe that high upfront costs associated with ZEB will hinder the integration of ZEB policies. Plus, if the purpose of investing is for resale, or leasing, then, an investor will determine the need of investing additional costs on ZEB. Overall, even after incorporation of ZEB policies, this will somehow remain a barrier in the foreseeable future until ZEB projects come into existence.

The high upfront investment costs are correlated with the need of models that consider both long-term and short-term goals of ZEB. For this reason, the homeowners consider the latter as a high-ranking barrier. As mentioned above, the literature highlights that high investment costs often prolong the payback periods, and this can be a concern for the transient population of UAE. Simply relying on the tenancy contracts and limiting the energy consumption are not enough to shorten payback periods. To make ZEB viable for the potential homeowners, investors, or even developers, it is worth exploring options such as power purchase agreements or FiT that can be the turning point. In addition to this, lack of education and training regarding ZEB is another barrier raised by the homeowners and this is discussed in earlier sections.

Moving on, homeowners have identified the lack of financial gains for the operators in maintaining the electrical grids another barrier for the ZEB policy-making process. Currently, the government of Dubai has enacted the Shams Solar Program, and this allows the homeowners to feed electricity into the grid. This concern is consistent with the study conducted in USA that discusses the impact of feeding the electricity into the grid, and its impact on the stability of the grid (Bruggmann, and Henze, 2018). However, there is a slight difference in the operations of the grids in the USA and UAE. In USA, depending on the area and the type of market, the generation, transmission, and distribution of electricity may or may not be managed by one entity. So, the distributor of electricity would need financial incentives for maintaining the grid. Whereas, in the emirate of Dubai, electricity generation, transmission, and distribution are the sole responsibilities of the government regulated authority called Dubai Electricity and Water Authority (DEWA). Also, the Shams Solar Program was launched by DEWA as well. So, in the UAE, the need of financial gains in maintaining grid may not be necessary as there is no third-party involved in management and distribution of electricity.

Lastly, the Table 13 highlights another social barrier for the homeowners i.e. change in the occupant's behavior to minimize the energy consumption. As discussed above, UAE experiences hot climatic conditions mostly. As a result, the energy consumption is high as well. To change the behavior of the occupants, the government of UAE has introduced slab tariff where an increase in energy consumption will lead to an increase in cost/kWh. However, one must not forget that energy is subsidized in the region (Krarti and Ihm, 2016). So, this poses a challenge to bring a drastic change in occupant's behavior to minimize the energy consumption. For these reasons, the homeowners believe that change in behavior to minimize energy consumption will face difficulties at the implementation stage of ZEB.

On the other hand, there is another reason for such high-ranking of this barrier by the homeowners. On being asked regarding the purchase of energy efficient appliances and water fixtures, only 55% of the respondents look for the energy-efficient labeling schemes prior to purchase. In comparing this with the overall set of responses, there increases to 59% only. By simply purchasing the energy-efficient appliances can assist in minimizing the energy consumption. However, this is not the case as occupants, or even homeowners often overlook the energy-efficient appliances at the time of purchase. The factors such as the age, efficiency, and frequency of usage of an equipment, or an appliance play a vital role in minimizing energy consumption (Shrestha and Kulkarni, 2013). So, to encourage well-informed decisions, ZEB policies can address the issue of occupant behavior by raising awareness on the use of energy-efficient appliances and equipment, above stated factors of the equipment and appliances, and mandating the use of highly energy efficient appliances and equipment.

4.2 Comparing Barriers with Other Countries

On comparing the results, lack of dissemination of knowledge among stakeholders is seen as a barrier in the decision-making process in Sweden, and Norway (Lindkvist et. al., 2014). This is consistent with the results of the respondents in the UAE. But the barrier is seen as a technical barrier, and whereas, in this paper, dissemination of knowledge is treated as a social barrier. In the technical group of barriers, in Norway, low and high energy ambitions is a barrier for ZEB (nearly). But, in Sweden, high energy consumption as a baseline for ZEB (nearly) is regarded as a barrier (Lindkvist et. al., 2014). Similar responses were also expressed by the respondents of the UAE, where establishing realistic baseline for energy consumption of ZEB is a high scoring barrier.

Next, in comparing the financial barriers, the responses of the UAE professionals are coherent with Australia, Norway, and Sweden's professionals. For instance, lack of financial incentives for pursuing ZEB (nearly) projects is seen as a barrier in Australia, Sweden, and Norway (Wells et. al., 2018; Matthew and Leardini, 2017; Lindkvist et. al., 2014). Elsewhere, there is an emphasis on the funding, and promoting the incentives of energy efficiency, and renewable energy (Thomas and Duffy, 2013).

In addition to this, UAE's respondents cited high construction costs, and longer payback periods as the barriers to implementing ZEB, which is also endorsed in Australia, Belgium, Norway, Portugal, and Sweden (Wells et. al., 2018; Lindkvist et. al., 2014; Carrilho de Graca et. al., 2012; Leckner and Zmeureanu, 2011; Audenaert et. al., 2008; Anderson et. al., 2006). Depending on the location around the globe, the ZEBs will typically require investments ranging between $8400-$15,166 above the building code requirements (Anderson et. al., 2006). In places like Sweden, and Norway, there is no return on investment for ZEB (Lindkvist et. al., 2014). Plus, in the case of Norway, as majority of the market is dominated by the homeowners, homeowners need to invest in the ZEB projects. This leads to initial investment costs like the high upfront costs highlighted by the UAE's respondents as a barrier.

Furthermore, it is estimated that the residents of Belgium would require a 9% increase in energy price on an annual basis to reap benefits within a 20-year mortgage plan. The people of Belgium who are willing to invest in ZEB, need to spend at least €37,000 as an initial cost (Audenaert et. al., 2008). Likewise, for ZEB to become cost effective, a similar study concluded that either prices need to increase by 13% annually, or technology becomes affordable. If not anyone of these, then a combination of both i.e. price and affordable technology (Leckner and Zmeureanu, 2011). Similar concerns of retrofitting costs, and energy prices are seen the Australian market as well (Matthew and Leardini, 2017). But comparing these concerns of energy prices are not seen in the case of UAE.

For the longer payback periods, in Australia, Boemi et. al. has estimated that a payback period for ZEB can vary between 7-23 years (Boemi et. al., 2015). Also, a study in Kuwait found out that payback period for energy efficiency, and solar integrated systems are between 0.5-3 years, and 14.1-16.1 years respectively (AlAjmi et. al., 2016). These results were similar in the Portuguese market as well. In Lisbon, the payback period of a ZEB is between 11 to 18 years (Carrilho de Graca et. al., 2012). These concerns are consistent with the longer payback periods identified as an economical barrier in the UAE. Moving on to the business models, there is limited research that presents the economic feasibility of ZEB including sustainable business models (Wells, et. al., 2018; Berry and Davidson, 2015; Linkvist et. al., 2014; Osterwalder and Pigneur, 2013).

In the social group of barriers, literature suggests that professionals can teach end users on operating and monitoring the homes that lead to maximizing energy efficiency, and lowering the energy costs (Thomas and Duffy, 2013).

Next, for the decision-making process, lack of standards is considered a barrier in the Sweden (Lindkvist et. al., 2014). Similarly, lack of policies supporting ZEB efforts are missing in countries such as Australia, and New Zealand (Wells et. al., 2018;). For instance, Matthew and Leardini have highlighted that until the legislation framework along with retrofit costs and change in energy prices are reflecting a positive impact on the ZEB in totality, building owners will most likely overlook to act on the energy efficiency measures in residential buildings of Australia (Matthew and Leardini, 2017). Likewise, the need of improving the energy requirements in the building sector is also recommended for the state of New England, USA (Thomas and Duffy, 2013). The lack of standards to implement ZEB policies is also a barrier in the UAE. Berry and Davidson have argued that regulations may drive the costs of ZEB initially. But, in the longer run, legislations often transform the markets by lowering the costs (Berry and Davidson, 2015).

4.3 Challenges

As discussed in the analyses of the challenges, the primary challenge is on-site generation for high-rise buildings. Similar concerns were also raised in the American region i.e. challenges in applying ZEB concepts to either sing-story, or multi-story buildings unless substantial site is available for renewable resources (Kibert, 2012). One of the challenges identified were the synergy between ZEB, and existing building codes. In Australia, there are concerns that optimizing existing buildings built on earlier building codes, and standards can be a challenge (Wells et. al., 2018). But, recent studies of converting existing buildings in Kuwait to ZEB by applying energy efficiency measures and installing PVs have shown that retrofitting can assist in achieving ZEB (AlAjmi et. al., 2016). Again, referring to the remarks of Kibert where the concern of significant site area for PV generation is raised, in Kuwait, the roof area used for PV was approximately 2950m^2 (approximately 30,000 ft^2), which is a significant area for PV portion. Back to energy efficiency measures on Kuwait's public building, this is consistent with responses obtained for the query regarding the potential of ZEB in the UAE. Majority of the respondents believe retrofitting existing buildings can contribute to the cause of ZEB. Moving on, another challenge for the UAE's respondent is the willingness to pay higher price for ZEB, or energy efficient building. As mentioned above, majority of the population is expatriates. Convincing an expatriate to spend high amount on ZEB will certainly be a challenge. However, this is not consistent with the evidences elsewhere. As seen in USA, UK, Europe, and Australia, housing prices are correlated with energy efficiency, thermal comfort, and minimum utility bills (Berry and Davidson, 2015; Department of Energy & Climate Change, 2013; Brounen and Kok, 2011). But again, the demographics have a role in the decision-making process for investment on ZEB.

4.4 Awareness of Existing Sustainable Policies in the UAE

This section will discuss the awareness, and practices of the respondents in the UAE. On being asked regarding the use of PVs in their residences, approximately 82.4% responded by saying No. However, on comparing the responses of types of rental contract against the use of PVs. It is seen that approximately 20% are capitalizing from the Shams Solar Program. This is because installing PVs, and maintaining PVs is an additional set of financial expense on the tenant. Hence, tenants would refrain from increasing the list of expenses.

Second, even though the entire group of respondents is working in the construction industry, the responses were equally divided when asked about the requirement of installing solar water heaters in Dubai. This shows that respondents are not that aware of the policies that are promoting sustainable practices. Third, respondents were asked if attention is given to Emirates Energy Rating system prior to purchase to fixtures and appliances. 59% of the respondents do look out for the labeling system, and the remaining often overlook the labeling system. This also depicts that at least half of the respondents are not concerned when it comes to purchase of energy efficient materials. This attitude can be since energy subsidies tend to be convenient for the end-use (Khondaker et al., 2016; Krarti and Ihm, 2016).

Moving on, in the next set of questions regarding ZEB, respondents were asked regarding the necessity of on-site renewable energy generation only. The responses were divided as follows: 35% were in favor of on-site generation only, 26% were unsure, and the remaining were not in favor of relying on on-site generation only. With experiences from the literature, for the UAE, it is preferable for supporting off-site generation initially. As the field of ZEB nurtures with the passage of time, the government of UAE can enact stringent codes with emphasis on on-site generation.

Then, respondents were also asked regarding the type of construction projects i.e. retrofit, or new construction that can be the focus of the UAE. Majority of the respondents i.e. 53% were in favor for both, 41% were in favor of new construction, and the remaining 6% were keen on retrofit projects only. Then, the respondents were asked about the building sectors that can implement ZEB concepts. Referring to Figure 11, the respondents believe that all the building sectors have the capacity to become ZEB. However, in literature, most of the emphasis are on the residential buildings, and with exception of commercial buildings in California. Lastly, the respondents were asked to identify the three building sectors for early adoption of ZEB codes. Majority of the responses were keen on ZEB codes for the villas, residential buildings, and schools.

4.5 Discussion on Governance Strategy for UAE

In earlier section, governance strategies of Denmark, California, and China were discussed. This section discusses the strategies the Government of UAE can pursue to achieve success in the ZEB.

As mentioned in the earlier sections, several strategies such as the UAE Energy Strategy 2050, DIES 2030, Dubai Clean Energy Strategy 2050 are in place on a federal, and emirate level for transition towards clean energy. However, UAE is devoid of policies for ZEB. Therefore, to understand the governance models of UAE, the paper will discuss the governance mode of the clean energy strategy.

Currently, the hierarchy mode of governance predominates the UAE on a federal, and emirate level. The federal Ministries of Climate Change and Environment, and Energy and Industry works with the local authorities of the seven emirates on the issues of sustainable environment, energy supplies and reduction in greenhouse gas emissions respectively (The Official Portal of the UAE Government, 2019). In fact, the goals set aside by the federal government are incorporated in the strategies of the emirates. For instance, as per UAE Energy Strategy 2050, the main objective of the federal authority is to increase the clean energy mix to 50%, whereas, the primary goal of the emirate of Dubai as per the Dubai

Clean Energy Strategy 2050 is to increase the energy mix of clean energy to 75% (Dubai Electricity and Water Authority, 2017; Ministry of Energy & Industry, 2017). The consistency in goals, and hierarchy mode of governance is evident in the targets. In fact, Dubai has set stringent measures to achieve the energy targets. Table 16 highlights the ministries that are working on a federal, and the corresponding authorities at an emirate level.

Table 16: Federal and Local Authorities of UAE

SN	Federal Authorities	Emirate	Emirate Authorities
1	UAE Government		
2	Ministry of Energy & Industry	Abu Dhabi	Department of Energy (Abu Dhabi)
		Ajman, Fujairah, Ras Al Khaimah, & Umm Al Quwain	Federal Electricity and Water Authority (FEWA)
		Dubai	DEWA
		Dubai	Dubai Supreme Council of Energy
		Sharjah	Sharjah Electricity and Water Authority (SEWA)
3	Ministry of Climate Change & Environment	Abu Dhabi	Environment Agency
		Ajman	Ajman Municipality
		Dubai	Dubai Municipality
		Fujairah	Fujairah Municipality.
		Ras Al Khaimah	Environment Protection and Development Authority
		Sharjah	Environment & Protected Areas Authority
		Umm Al Quwain	Umm Al Quwain Municipality

Besides this, on an emirate level, several local authorities work collaboratively to achieve the goals set by the emirate, which is an example of network-based governance. One such example of network-based governance can be seen under the umbrella of Dubai Supreme Council of Energy (DSCE). Local authorities such as Dubai Municipality, and DEWA work with DSCE to achieve the goals of clean energy set in DIES 2030 (The Official Portal of the UAE Government, 2019; Dubai Supreme Council of Energy, 2017).

In the emirate of Abu Dhabi, there is a precedence of network-based governance as well. Masdar, a government owned subsidiary formed with the purpose of developing clean energy solutions has several divisions that work collaboratively (The Official Portal of the UAE Government, 2019). Besides this, with the recently introduced Dubai Clean Energy Strategy 2050, the emirate of Dubai is paving way for market-based mode of governance as well. Through this strategy, government will provide financial support with easy loans at lower interest rates to the investors (Government.ae, 2018). These incentives encourage the society to actively participate in the governmental programs. The following table summarizes several goals set aside by the federal & local authorities of the UAE.

Table 17: Goals of Federal & Local Authorities

SN	Initiatives & Targets of Federal Authorities	Purpose
1	Sustainable Environment & Infrastructure under the UAE Vision 2021 (UAE Government)	to improve air quality, preservation of water resources, increasing the clean energy proportion (27%), and implementation of green growth plans (UAE Vision 2021, 2014)
2	UAE National Innovation Strategy (UAE Government)	innovations in sectors including but not limited renewable energy, water, and transportation (UAE Ministry of Cabinet Affairs, 2015)
3	National Environmental Education and Awareness Strategy 2015-2021 (Ministry of Climate Change & Environment)	to educate the youth about sustainability, and the role of society towards achieving sustainability, and protection of environment (UAE Ministry of Climate Change & Environment, n.d.)
4	National Climate Change Plan of the UAE 2017–2050 (Ministry of Climate Change & Environment)	roadmap of climate mitigation (UAE Ministry of Climate Change & Environment, 2017)
5	UAE Energy Strategy 2050 (Ministry of Energy & Industry)	a clean energy mix of 44% clean energy, 38% gas, 12% coal, and 6% nuclear. Targeted investments of AED 600B. (Ministry of Energy & Industry, 2017)
6	Deregulation of Fuel Prices (Ministry of Energy & Industry)	
SN	Initiatives & Targets of Emirate (Local) Authorities	Purpose
1	Environment Vision 2030 (Abu Dhabi)	work in the following areas: climate change, air and noise pollution, water resources, preservation and enhancing natural heritage, and waste management (EAD, n.d.)
2	Masdar Initiative (Abu Dhabi)	a government owned subsidiary with the purpose of investments in clean energy (The Official Portal of the UAE Government, 2019)
3	Dubai Integrated Energy Strategy 2030	generating energy for clean resources; 12& from clean coal, 12% of nuclear, 5% from solar, and 71% from natural gas. Works in coordination with several authorities of Dubai such as DEWA, and Dubai Municipality (Dubai Supreme Council of Energy, 2017)
4	Dubai Clean Energy Strategy 2050	one of the targets is to increase the clean energy mix: 25% solar energy, 7% nuclear energy, 7% clean coal, and 61% gas with gradual increase of clean energy to 75% in the energy mix by 2050 (Government.ae, 2018).

Connecting the solar energy to the Dubai's (DEWA) power grid is another example of market-based governance. In 2014, under the Executive Council Resolution No. (46) of 2014 Concerning the Connections of Electricity of Generators from Solar Energy to the Power Distribution System in the Emirate of Dubai, Dubai encouraged the developers, and homeowners to generate electricity through photovoltaics (PVs), and connect it to DEWA's power grid. As a result, this paved way to transfer surplus electricity to the DEWA's grid, and since then, 50MW of rooftop solar PVs were deployed (IRENA, 2019). In fact, over the past 5 years, UAE was at the forefront of installed RE capacity i.e. mainly PVs, and CSP. Up until 2018, UAE has installed 587MW of RE, since 2014, there is a threefold increase in the energy generated from solar resources i.e. 140MW (IRENA, 2018; The Official Portal of the UAE Government, 2019). As of 2018, UAE's clean energy contribution in the energy mix was 0.35% (UAE Vision 2021, 2019). The target set for clean energy under the UAE Vision 2021 is 27% (UAE Vision 2021, 2014).

Overall, in UAE, there are glimpses of hierarchy, network, and market-based governance. Hierarchy mode of governance is the predominant mode of governance on a national level. Whereas, network, and market-based governances exist on an emirate level. To provide a framework for ZEB, UAE can focus on market-based governance for stimulating ZEB in the society. This will accelerate the transition towards ZEB, and assist in meeting several federal, and emirate level goals. As seen in the case of California, where large number of ZEBs were certified, and verified because of market-based governance (New Buildings Institute, 2018).

4.6 Business Model for ZEBs in the UAE

As discussed above, there is a dire need of sustainable business model that encourages ZEB. This can also support the renewable energy generation. Currently, the only program encouraging the homeowners is the renewable energy generation is Shams Solar Program. Under this, individual homeowners are installing rooftop PVs, and supplying extra energy to the grid. But, as seen in the responses, majority of the users are not capitalizing on this program. Another analysis depicts that majority of the respondents on the rental contract are not capitalizing on the Shams Solar Program. One of the reasons being the costs associated with the installation, and later, operating and maintenance costs. For a person on a rental contract, this is an additional cost. So, the priority is to engage people on rental contracts to engage in Shams Solar program. One of the options is to encourage energy generation from renewable resources, and without confining it to homes. This will encourage participation of private sector to pursue such projects i.e. purchase of lands and install PVs for generating electricity. The electricity generated is transferred to the grid. Then, the electricity is supplied to the national grid, and then, the end-users can purchase from the grid. In ideal situation, many renewable energy generators are competing in providing competitive rates to the end-users. End-users can engage in long-term power purchase agreements for consistency, and reliance on the systems. One advantage for the end-user is eliminating the need to maintain or replace the PVs as it falls under the responsibility of the PV energy generator.

The following figure depicts the scenario where the different renewable energy generators are supplying energy to the grid, which is then transmitted to the end-users. This is identical to the concept of wheeling of power in practice especially in the North America where end-users can look out for cheaper suppliers of electricity than the one present in the nearby vicinity of the end-user.

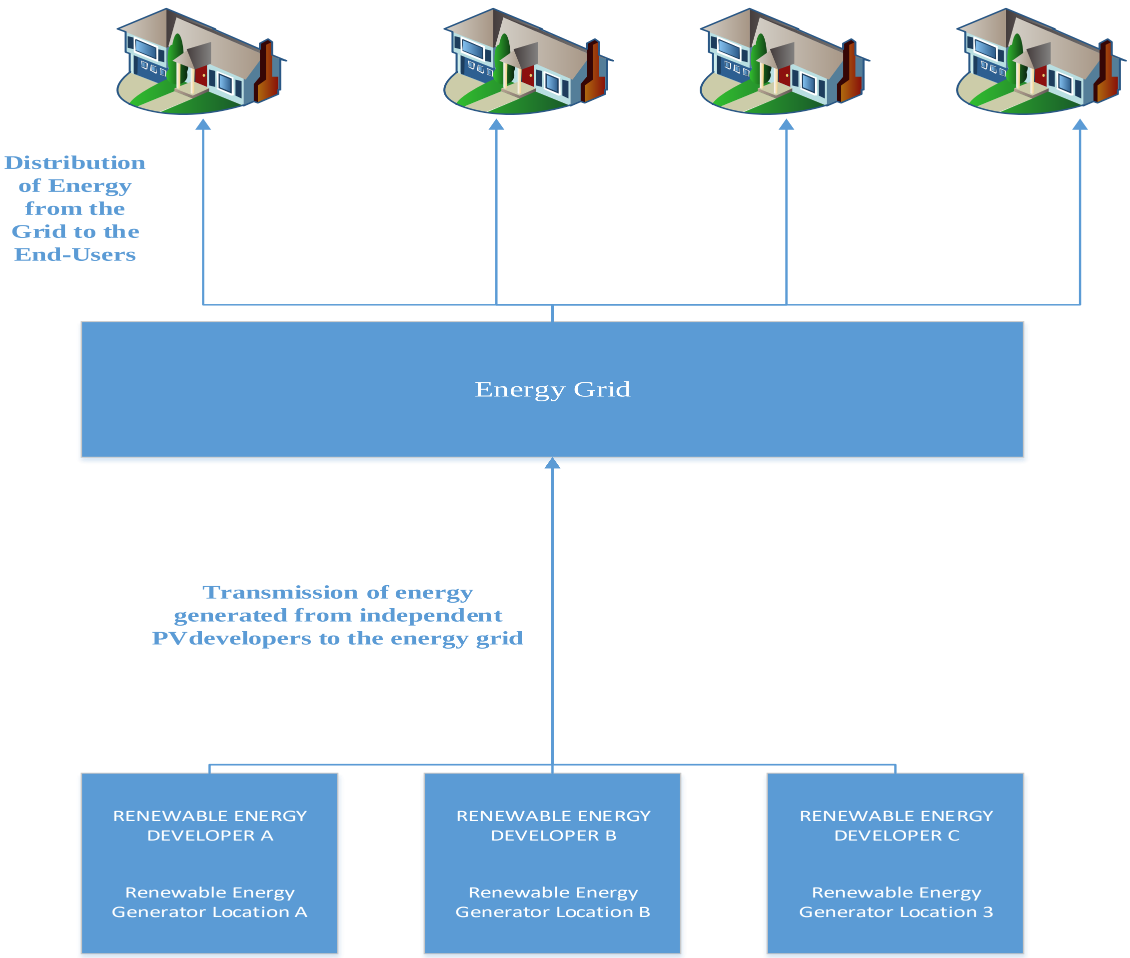

Diagram 2: Proposal of Sustainable Energy Model

But the above proposed strategy would require government support on the following conditions.

For the developers, installing PVs is a three-tier process. First, is the purchase of land, then, construction and installation of PVs, and at last, supply of electricity to grid at an agreed rate with the grid operator. From encouraging a developer perspective, one strategy worth exploring is the investment tax credit policy. From an end-user perspective, the user gets the opportunity to explore multiple suppliers of renewable energy and choose the least expensive renewable energy supplier under the power purchase agreement. Secondly, it encourages end-users who are engaged in a rental contract to pursue energy generated from renewable resources. As a result, energy requirements are being met through clean energy. Third and last, it will also assist in accelerating the transition towards ZEBs in the UAE. As a result, overall reduction of greenhouse gas emissions in the UAE, and support in achieving the goals UAE Clean Energy Strategy 2050.

Moving on, in terms of constructing ZEB, based on the responses and the literature review, it is certain that high-rise, or villas can achieve ZEB status in the UAE. However, achieving ZEB status from on-site generation will be an uphill task, or even improbable. To tackle this, one possibility is to encourage ZEB on a community level instead of focusing on a single property, or even off-site generation. The following figure is another proposal for encouraging the ZEBs. For the above business models, one important aspect for consideration is the transient nature of the people. Most often, the expatriates come in the region on short-term assignments with goal of moving back to their respective country. As mentioned, major share in the population of the UAE is of the expatriates, hence, the focus should be on financial incentives in such manner that encourage most of the population to pursue ZEB.

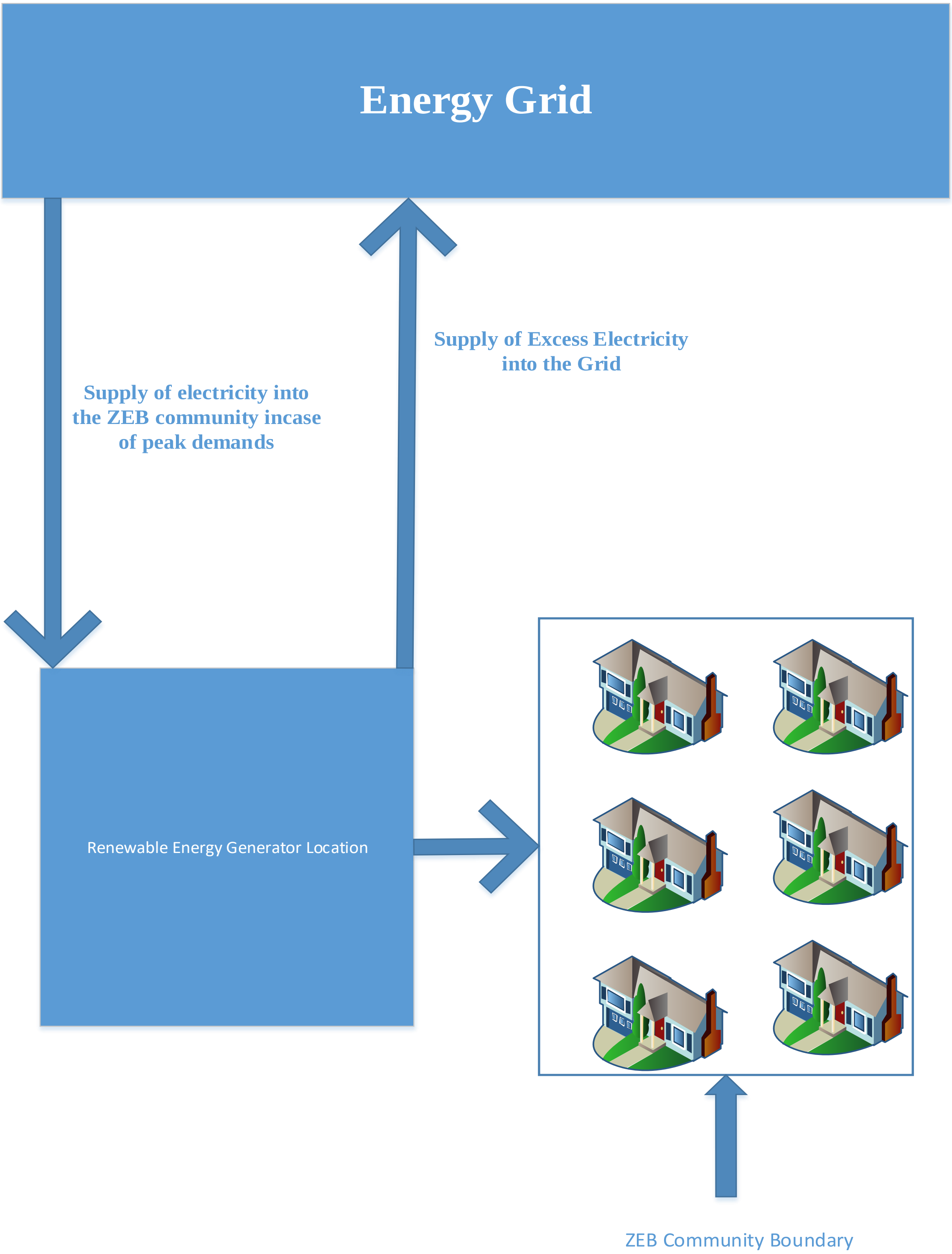

Diagram 3: ZEB Community

In Diagram 3, it is seen that there is a separate plot for generating renewable that provides electricity to the ZEB community. In case. there is a need of additional electricity, the community can take electricity from the grid, and in other case, supply extra energy into the grid. This model entails a risk of separate investment of acquiring property for generating energy. From a developer's perspective, the area can be used for other revenue generating projects. However, legislation providing rebates, and ensuring future projects must consider ZEB codes will play a crucial role. On the contrary, there is an advantage for the developer i.e. exceeded amount of electricity will result in savings for the community, and even financial gains for the developer. This can be through policies such the FiTs.

Another option worth exploring is a power purchase where the developer, and the grid operator bind into an agreement for purchasing an agreed rate, and quantity to ensure certain targets are achieved in terms of renewable energy generation, and ZEB status. In this scenario, to encourage renewable energy generation, the maintenance can fall under the developer (facilities management), and these can be charged to the end-user. Overall, governments should focus on legislations that create a balance between economic growth, and environmental. As seen in the case of Tokyo where it is only responsible for 5% of Japan's CO_2 emissions, but it generates approximately 17% of Japan's GDP (Fujita and Hill, 2007).

Chapter 5 – Conclusion & Recommendations

To sum up, even though there is a lack of consistency in the definitions, ZEB can be the answer to curb greenhouse emissions by combining energy efficiency measures, and reliance on renewable energy to meet the energy requirements of the buildings in the UAE. So far, there are no codes in place that support ZEB in the UAE. Based on the survey, several barriers were identified that hinder the implementation of ZEB policies. Majority of these are economic barriers such as high upfront costs, and lack of financial incentives, and longer payback periods. Through the survey, it is also seen that even though several sustainable policies are enacted in the UAE, the public is not incorporating these practices in their daily routine.

To promote ZEB in the region, the government must focus creating policies that support ZEB, encourage the society to invest in such projects, and create awareness of energy efficiency measures. More importantly, these ZEB codes and standards must be coexisting, and meet the goals of the existing policies such as the DIES 2030, DIES 2050, and UAE Clean Energy Strategy 2050.

Moving on for future legislation in the UAE, the government can focus on villas, schools, and especially hotels, and religious institutions for early adoption of ZEB codes and standards. First, in the case of villas, several case studies and examples exist around the globe that endorse ZEB. Hence, the implementation of ZEB codes for the villas will not be a concern. Second, in the UAE, the government can focus on the education sector for two reasons: schools are occupied for certain period in a day, and these schools are closed during the summer period when there is steep rise in the peak loads. Due to the duration and period of occupation, schools have the potential of achieving the ZEB status. Another reason for making a case for the schools is the students itself. On witnessing such practices in their daily routine, the young generation will ensure that sustainable practices are brought in their daily life as they flourish with time.

Third, the UAE is a tourist attraction, and the number of visitors in the UAE continue to rise for the past decade. For this reason, ZEB codes and standards can be applicable for the hotel sector as well. There is an abundant supply of hotel keys in the UAE, and if ZEB is implemented in this sector, the results will be encouraging. In fact, the UAE can encourage other countries that rely heavily on the tourism to pursue ZEB.

Next, another important aspect is the need of business models that encourage transition towards ZEB. As seen in the case of PVs, the government of UAE can enact similar policies that support the cause of ZEB. UAE is leading in the GCC when it comes to electricity generation from renewable resources. Also, the governance mode must be market-driven that encourages integration of ZEB policies.

Last but not the least, the UAE must also focus on sustainable growth. UAE continues to feature as one of the leading countries in terms of CO_2 emissions per capita. The sustainable economic growth must contribute to the GDP, and at the same time ensures that environmental equity is not overlooked. Future research can focus on establishing realistic energy consumption model for ZEB in the UAE with focus on the hospitality industry.

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APPENDIX

Problems in Implementing Zero Energy Building Policies in United Arab Emirates

Zero Energy Building (ZEB) is defined as a building that produces enough renewable energy to meet its own annual energy consumption requirements. Several terms are used to state ZEB such as Zero Net Energy, Net Zero Energy, or nearly Zero Energy Buildings. The first four questions are general information , and the remaining questions are focused on the problems of implementing ZEB policies.

Section 1 ...

General Information

This section focuses on the information of the respondents

1. Please select your range of working experience in the construction industry *

- 0 - 5 years
- 5 - 10 years
- 10 - 15 years
- greater than 15 years experience

2. Your Company is: *

- Local Office (UAE only)
- International

3. Role of your company *

- Contractor
- Designers/Architects
- Project Management Consultants
- Client
- Other
- Other

4. If the above response is other, please mention the industry of your expertise *

Enter your answer

5. Working Sector *

- Private
- Public

6. Type of residential property *

- Home owner
- Rental contract

7. Size of the residential property *

- 0-1000 sqft
- 1000-2000 sqft
- greater than 2000 sqft

Section 2 ...

Review of Problems & Challenges for Implementing ZEB Policies

This section requires the respondent to rate the technical, economical, social, and legal barriers for implementing zero energy building (ZEB) policies.

8. Technical Problems *

	5	4	3	2	1
Lack of Technical Expertise of ZEB Concepts,	○	○	○	○	○
Lack of previous experience in ZEB projects, and lesson learnts	○	○	○	○	○
several definitions to define ZEB creates confusion	○	○	○	○	○
Establishing realistic baseline for energy consumptions of ZEB	○	○	○	○	○
Differences in Predictive vs Measured Performance of Buildings	○	○	○	○	○
Technical Limitation of ZEB to single-story or multi-story buildings due to the energy consumption requirements of ZEB	○	○	○	○	○
Substantial on-site area to generate renewable energy	○	○	○	○	○
High Residual Loads and its Impact on grid stability	○	○	○	○	○

9. Economical Problem *

	5	4	3	2	1
Effect of high energy subsidies on the ZEB	○	○	○	○	○
Lack of Financial Incentive to Implement ZEB	○	○	○	○	○
High upfront investment costs	○	○	○	○	○
Longer payback periods	○	○	○	○	○
Need of business models that consider short term and long term goals of ZEB	○	○	○	○	○
Lack of financial gains for the grid operators in maintaining electrical grid	○	○	○	○	○
Economic considerations influencing the decision-making process for investing on ZEB, and energy efficient measures	○	○	○	○	○
long term impact of lowering operations & maintenance costs; no short term impact	○	○	○	○	○
loss of revenue for vacating building to retrofit a building	○	○	○	○	○

10. Social & Cultural Problems *

	5	4	3	2	1
lack of disseminating knowledge of ZEB among stakeholders,					
architectural and cultural values of a building limiting the true potential of ZEB technically					
lack of awareness regarding the concept of ZEB					
participation and engagement of stakeholders					
lack of education and training regarding ZEB					
envrionmental and health concerns when a ZEB building is occupied					
change in occupant behavior to minimize energy consumption , and contribute to the cause of ZEB					

11. Legislative Problems *

	5	4	3	2	1
Lack of standards to implement ZEB					
subsidies on energy prices (low energy prices)					
existing policies and standards hinder ZEB goals					
lack of legal frameworks, and laws for implementation					
lack of insurances/liability					
lack of long-term assurances by the authorities for pursuing ZEB					

12. Challenges of ZEB *

	5	4	3	2	1
As required by ZEB, on-site generation will be a challenge for high-rise buildings					
Agreeing to a universally accepted ZEB definition					
willingness to pay a higher sale value, or rental price for ZEB, and energy efficient buildings					
synergy between ZEB codes, and existing codes polices					

Section 3 ...

Existing UAE Policies & Potential of ZEB

This section focused on the existing energy related policies enacted in the UAE, and the future possibilities of ZEB in UAE

13. Use of Renewable Energy in the Residential Sector *

	Yes	No
Currently, are you benefitting from the Shams Solar, or any other closely affiliated renewable energy program?	○	○

14. Solar Water Heaters *

	Yes	No
Are you aware of the requirements of solar water heaters in the buildings (Dubai)	○	○

15. Are there solar water heaters deployed in your building of residence *

- Yes
- No
- Maybe

16. For future ZEB policies, should UAE rely on on-site renewable energy generation only? *

- Yes
- No
- Maybe

17. Before purchasing electrical appliances, or water fixtures, do you look for Emirates Energy Rating System? *

- Yes
- No

18. Incentives to pursue ZEB programs *

	Extremely Important	Somewhat important	Neutral	Somewhat not important	Extremely not important
As a resident, how crucial is the financial incentive to pursue ZEB programs for minimizing energy consumption?	○	○	○	○	○

19. What type of construction projects should be the priority of the authorities for ZEB *

- Retrofit existing buildings
- New Construction
- Yes for both

20. Which type of the building sector has the potential of achieving ZEB in UAE *

	Yes	Maybe	No
Villa	○	○	○
Schools	○	○	○
Residential upto G+4	○	○	○
Residential High-rise (greater than G+4)	○	○	○
Hospitals	○	○	○
Offices	○	○	○
Hotels	○	○	○
Malls	○	○	○
Public buildings such as ministries, parks, and libraries	○	○	○

21. Name the three building sectors mentioned in "Question 20" for early adoption of ZEB policies in UAE? *

Enter your answer