EmiratesGBC
مجلس الامارات للابنية الخضراء
Emirates Green Building Council

Defining
Nearly Zero Energy Buildings
in the UAE - 2017

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Emirates Green Building Council is a business forum based in the United Arab Emirates formed in 2006 with the goal of advancing green building principles. The Council gathers member companies and partners representing a diverse range of stakeholders from within the building industry, government, and academia. EmiratesGBC functions as a common platform for all stakeholders whereby they can meet, discuss, interact, and exchange groundbreaking ideas which help to promote a sustainable built environment in the UAE and the surrounding region.

Since its formation, EmiratesGBC has initiated several programs and events related to improving the operational efficiency of existing buildings. Membership is open to all stakeholders willing to influence a positive change in the country's built environment. The Council facilitates open engagement with its members and conducts quarterly review with its Board Members to devise work plans and programs which promote the Council's mission.

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Executive Summary

The development of Nearly Zero Energy Buildings (nZEBs) is an essential measure to support the UAE's pledge of combating global warming at COP 21 in 2015, its ratification of the Paris Agreement in 2016, the UAE Vision 2021, Dubai Plan 2021, and Abu Dhabi Plan 2030. The adoption of nZEBs provides the quantum leap from current business as usual to the development path required to achieve the aforementioned pledges and strategies. It also provides an important stepping-stone to the achievement of a net positive built environment and a decarbonized global economy, where economic growth and environmental degradation are decoupled.

The Defining Nearly Zero Energy Buildings in the UAE – 2017 EmiratesGBC Report offers a definition for nZEBs that can be used as a reference to support a strategy for the development of nZEBs in the UAE. This report runs in parallel to global trends of transitioning towards a low carbon, low energy economy and subsequent development of nZEBs. As part of this Report, various concepts and global implementations of Zero Buildings were reviewed by EmiratesGBC with a particular focus on nZEBs. Current UAE initiatives, strategies, building codes and rating systems were also investigated to highlight the role nZEBs can play in the UAE's holistic approach to sustainability within the built environment. Case studies were used to showcase low energy buildings in the UAE to validate the feasibility of the concept. Additionally, a survey was conducted to solicit stakeholder recommendations to define nZEBs in the UAE.

As a result of this study, the following can be summarized:

- nZEBs are a globally adopted concept with clear targets set in the United States, Australia and in particular EU Member States, with a general timeline of 2020-2030 set for adoption of the concept.
- The concept of nZEB strongly aligns with and supports the UAE National Vision and commitments, particularly with respect to innovation in sustainable energy.
- Early adopters of the concept of nZEB in the UAE already exist with a number of demonstrable cases of nZEBs in the market. This validates that the time is appropriate to transition from an 'early adopter' state to 'mainstream adoption'.
- Stakeholders generally agree that the market will be ready for the adoption of the nZEB concept between 2020 and 2030.
- In accordance with international practice and stakeholder feedback, it is recommended to commence with the introduction of the concept in the public sector prior to roll out in the private sector.
- Cost is an important consideration for nZEBs and any nZEB action plan should be cost effective and hence focus on aggressive passive measures – a similar strategy adopted by many EU Member States.
- Based on the large number of high-rise buildings in the UAE, it is recommended to consider renewable energy beyond the plot boundary within the nZEB consideration. This can take the form of district renewable energy systems or potentially extend to regulated Renewable Energy Certificates.

Based on the stakeholder analysis, analysis of the market and review of case studies, an initial nZEB definition for residences and offices in the UAE can be considered to be:

A Nearly Zero Energy Building (nZEB) in the UAE can be defined as a highly energy efficient building with a site EUI less than 90 kWh/m^2/year and covers a significant portion of its annual energy use by renewable energy sources produced on-site or off-site.

Foreword

In recent years, the leadership in the UAE has been introducing a number of vision statements and measures to encourage, urge and support the industry's multiple stakeholders to raise the bar on building performance.

Since its inception in 2006, Emirates Green Building Council (EmiratesGBC) has focused on promoting dialogue and positive action in green buildings and sustainability of the built environment across various sectors in the United Arab Emirates. As an independent entity supporting the evolution of the country as a green economy, EmiratesGBC brings together stakeholders from across the industry, academia and government to share insights and identify actionable solutions to achieve a more sustainable future.

We cannot deny the fact that buildings are a major contributor to the carbon footprint of any country. In the UAE, over the last ten years, EmiratesGBC has set initiatives and programmes that have championed strategies aimed at achieving the rigorous sustainability targets set by the government.

The Nearly Zero Energy Buildings (nZEBs) strategy is one such approach underpinned by the Paris Agreement on climate change, which requires decarbonising our economy. Buildings with energy needs met entirely through renewable energy are called net zero energy buildings. The stepping-stone to reach net-zero is nZEBs, which use low net amounts of energy and meet much of its own requirements through renewable generation.

It is essential that nZEBs form an important part of UAE's overall sustainability strategy. The definition of an nZEB must be flexible towards system boundaries. It is not a case of setting a number and leaving it. There is a need to balance it with other factors, such as economic growth. The overall mission is to decarbonise, and there is a global impetus to mitigate climate emission, which the UAE has signed up for.

From defining the concept of 'zero energy' to identifying important factors on how best we can work together to achieve nZEBs, this report will support and advise industry stakeholders and policy makers to work together, innovate and achieve Zero status. When it comes to the green building movement, the UAE has led the way in the region and we can set further benchmarks globally through collaborative action by the industry and greater public participation in energy management.

On behalf of EmiratesGBC, I thank all those participating projects and organisations for their contribution to this study.

We are confident that the outcomes of this report will support and foster further developments of nZEBs in the UAE.

Saeed Al Abbar
Chairman
Emirates Green Building Council

Introduction

Worldwide Trend

Buildings are a substantial contributor to climate change as they account for one third of the global greenhouse gas emissions, as well as 40% of the total primary energy consumption in the world [1]. To address the high energy use of buildings and the consequent environmental impacts, several initiatives and codes have been set as minimum requirements for design, construction and operations. The level of building requirements, stringency of building codes and buildings' energy performance targets vary between countries due to factors such as climate, economics, politics, culture and awareness as well as the level of ambition to improve the built environment efficiency.

Accordingly, several high performing building concepts have emerged that include: low energy buildings, zero energy buildings (ZEBs), nearly zero energy buildings (nZEBs) and passive buildings.

In Europe, under the Directive 2010/31/EU (Energy Performance of Building Directive-EPBD), Member States have set a target for all new buildings to be nearly zero energy buildings by 2020 [2]. Similarly, in the US, in the State of California the target is to achieve net zero energy buildings for all new residential and commercial buildings by 2020 and 2030, respectively [3].

On a global scale, the World Green Building Council has announced Advancing Net Zero, a global project which aims to ensure that all buildings have zero carbon emissions by 2050. As part of the Advancing Net Zero project, Green Building Councils have been invited to launch zero carbon certification programs, create specialized net zero training for green building professionals, and support the development of net zero demonstration projects in their countries.

As of November 2016, 10 countries (Australia, Brazil, Canada, France, Germany, India, Netherlands, South Africa, Sweden and the US) have committed to introduce a net zero carbon certification system for their market by early 2018, as well as setting and tracking targets on implementing pilot projects and training the sector towards net zero carbon [4].

Several pilot projects have demonstrated the feasibility of the ZEBs concept, which has in turn resulted in increasing numbers of ZEB projects in recent years. For example, according to the Net Zero Energy Coalition's inventory, there are 6,177 net zero energy residential units in the US and Canada, which are either completed, under construction or still in the design phase, as of 2015 [5]. Outside North America, there are 411 nZEBs (recently constructed or renovated as of 2017) that are located in 17 European countries, out of which 64% are residential and 36% are non-residential [6].

The above demonstrates that there is a palpable increase in the number of successful 'zero building' projects and a clear commitment by public and private sector stakeholders to create rapid change in the built environment through the advancement of zero energy buildings.

Buildings in the UAE

The reduction of building energy consumption is a priority for the UAE government, particularly since buildings in the UAE have been found to consume up to 70-80% of the country's total electricity generation. Existing buildings play a prominent role toward inefficiency in the UAE's built environment. In Dubai, for instance, 25% of the existing building stock has been identified as inefficient and has a high energy saving potential, according to Dubai Supreme Council of Energy (DSCE) [7]. Recent research has evaluated the potential for energy improvement in UAE's

existing buildings, with one such study conducted in 2013 estimating that the saving potential can reach up to 30.8% in UAE public houses [8].

In addition to research and development, national strategies, policies and codes have been developed to improve the design and performance of buildings in the UAE. In Abu Dhabi, the Estidama Pearl Rating System (PRS), which launched in 2010, is now used as a mandatory guideline for green building regulations for new-construction villas, buildings and community projects. Dubai has also mandated a green building code, Dubai's Green Building Regulations and Specifications (GBRS), on government owned buildings since 2011 and on all new buildings in Dubai since 2014. Following the GBRS, Dubai Municipality has introduced Al Sa'fat rating system in 2016, in order to advance the performance of the built environment and support the goal of the Dubai Plan 2021 to create a sustainable city.

Nearly Zero Energy Buildings (nZEBs) in the UAE

Considering the advancements in the UAE's building codes and the UAE's vision to position the country at the forefront of sustainable energy, the concept of nZEBs is very important to the UAE national agenda as it aligns with the key priorities of the country of driving innovation and sustainability.

The applicability of nZEBs in the UAE raises several questions; what is the achievable target of nZEBs in the UAE? What are the metrics and the key performance indicators of nZEBs? and what are the barriers and measures to reducing energy consumption in UAE's buildings?

Emirates Green Building Council (EmiratesGBC) has conducted a research and analytic study, summarized in this report, to support the industry, government and other stakeholders in answering the above questions and build capacity towards mainstreaming the adoption of nZEBs. This report, therefore, includes:

- research on the global definitions and targets of nZEBs;
- examination of the UAE's policies for the improvement of building energy efficiency;
- studying existing best practice projects in the UAE;
- stakeholder consultation and survey.

Defining "Zero"

Historically, a Zero Energy Building (ZEB) has been interpreted as an off-grid building with an autonomous energy supply [9]. Renewable energy and distributed generation systems were considered to supply and operate these buildings. In some cases, and in order to overcome the seasonal mismatch between demand and supply, these renewable energy systems were oversized. This raised concerns with regards to the loss of generated energy, environmental impacts of the storage systems and other sustainability issues. To address these matters, the concept of ZEB was reviewed to consider (in priority):

1. reducing the energy demand;
2. installing energy efficient equipment;
3. relying on the public grid as a sink and/or source of energy.

In order to better understand the principal behind the emerging definitions of ZEBs, it is important to review the existing buildings concepts and identify the factors influencing them. Government organizations, nonprofit's, and industry stakeholders have developed their own definitions of ZEBs in the absence of an international standardized definition and lack of unified building performance measures that could advise ZEB policies and programs [10].

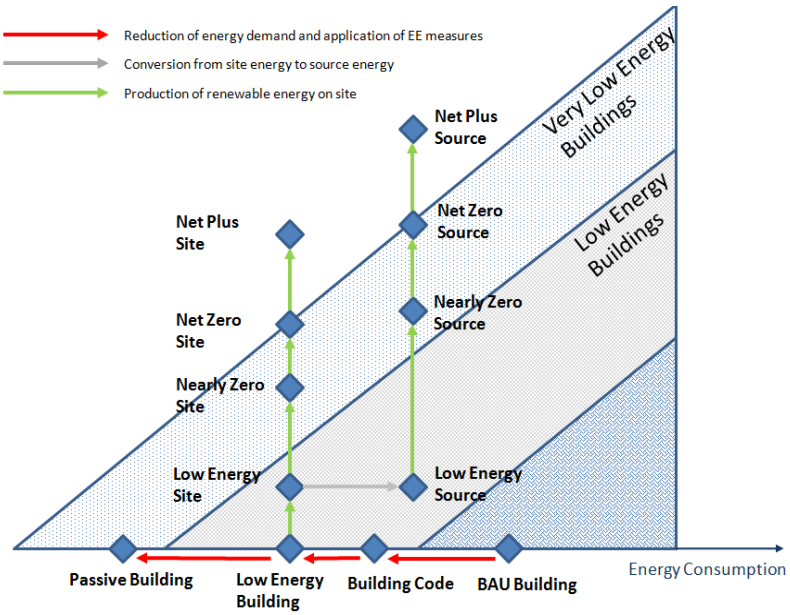
The metric of evaluation of ZEBs changes significantly according to the different stakeholder priorities. For instance, owners care about cost; national energy organizations are interested in primary energy sources; building designers are interested in site energy code requirements, while those who are active environmentalists care about emissions [11]. Besides stakeholder priorities, factors like energy balance boundary, renewable energy supplies, and connection to the energy infrastructure need to be considered when developing a target for ZEBs [12].

Some of the existing concepts of ZEBs are illustrated in Figure 1. Compared to Business as Usual Buildings (BAUs), energy efficient buildings have either applied energy conservation, energy efficiency and/or energy demand reduction measures to reduce their consumption and costs. Several energy efficiency levels can be achieved based on the applied building codes and the considered project-related energy reduction targets. For instance, a Passive Building has a significant energy reduction target to eliminate the need for any conventional active heating or cooling system as well as maintaining good comfort level and indoor environmental conditions [13].

Due to cost effectiveness of energy efficiency measures compared to renewable energy, buildings prioritize reducing their energy consumption before considering renewable energy sources.

Renewable energy, however, plays a critical role in Nearly Zero Energy Buildings, Net Zero Energy Buildings and Net Plus Energy Buildings. It has been widely adopted as a primary energy source in these buildings to balance the energy use after demand and energy reduction. The difference between the energy consumption and energy generation reflects the ZEB target (refer to Figure 2). Renewable energy can be either produced on-site or transported to the site. On-site generation includes renewable energy systems installed on the building footprint or on the land beside the building, while off-site generation embraces investments in off-site renewable energy technologies or purchase of green power [12].

Figure 1: Existing energy efficient and zero energy buildings concepts. The diagram is a graphical representation, not to scale, and is not a reference for comparing the level of energy performance of the existing definitions.



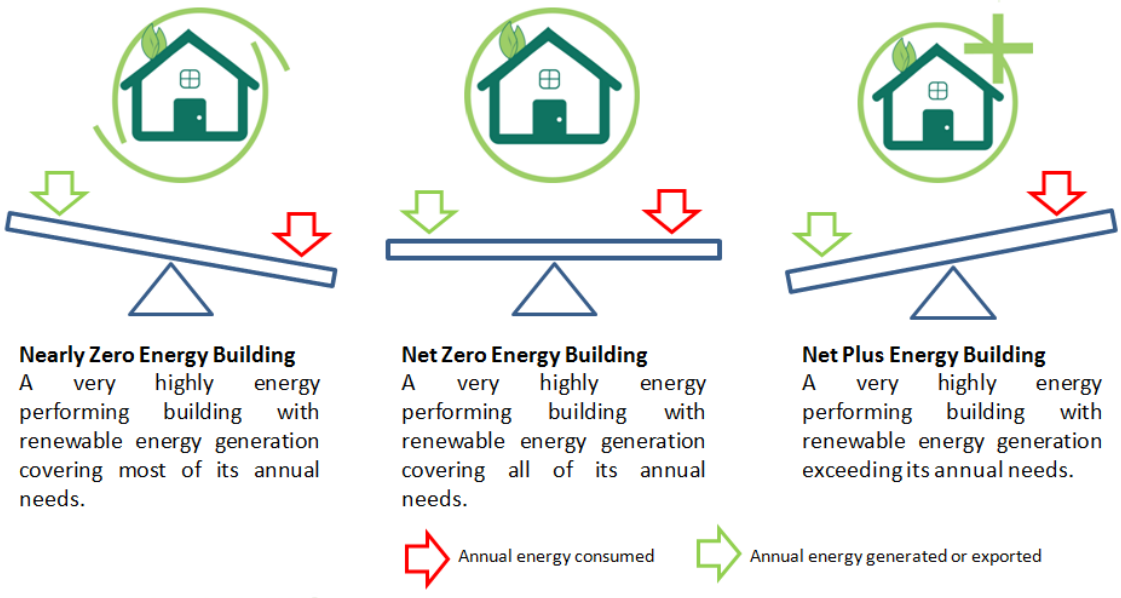
According to the European Union Commission, a nearly zero energy building is defined as a building that has a very high energy performance as determined on the basis of the calculated or actual annual energy consumed [14]. Furthermore, the nearly zero or very low amount of energy required for the building consumption should be covered to a significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby [14].

Another important parameter that should be considered while defining a ZEB is the energy balance boundary, keeping in mind that buildings consume diverse sources of energy including on-site use of fossil fuels, electrical energy, renewable energy and thermal energy from district cooling and/or heating systems. The energy balance boundary can be accounted for at either the site or the source.

On-site energy considers only the amount of fuel and electricity that is consumed by the building as reflected in the utility bills. Thus, the final energy is the only consideration for on-site energy balance. On the other hand, when applying a source energy balance, primary/source energies are evaluated by incorporating the transformation (for example, from oil into electricity), transmission and delivery losses (refer to Figure 1). According to the US Environmental Protection Agency (EPA), the source energy is the most equitable and favorable unit of evaluation because it better expresses the energy efficiency status of buildings [15].

Further regulations and policies can also heavily dictate the implementation of ZEBs. For instance, under the Directive 2010/31/EU, each Member State must meet the energy performance targets set whilst achieving cost-optimal levels. Cost-optimal levels are defined as the energy performance level which leads to the lowest cost during the estimated economic lifecycle [16]. Each Member State is thus directly responsible for determining this level and can include a range of costs such as maintenance costs, operational costs and energy savings. They are also required to report this result to the European Commission, who then assess and reports the progress of each Member State in reaching cost-optimal levels [2].

Figure 2: Definitions of nearly, net and plus energy buildings.



Yet, other concepts like Net Zero Energy Costs, Net Zero Carbon Emissions and Net Zero Exergy consider different approaches and metrics. For instance, Net Zero Carbon Emissions Buildings is defined by the World Green Building Council as a highly energy-efficient building utilizing all remaining operational energy use from renewable energy to achieve net zero carbon emission annually [17] and is currently being used as the key measurement metric for their Advancing Net Zero Project. On the other hand, Net Zero Exergy Buildings produce as much energy at the same grade or quality as consumed on an annual basis [18]. Exergy incorporates not only the quantity of energy, but also the quality of energy, thus further assessing the impact of the building on the environment.

Zero Energy concepts may also go beyond a building's boundary, and extend to districts and cities. For instance, Net Zero Energy Districts are groups of buildings such as a city district, communities or campuses with a target of net zero energy [3].

It is not possible to define a nZEB target in the UAE without examining global nZEB targets to aid in the establishment of a viable target in the UAE. Therefore, the primary energy targets for nZEBs of various countries, along with their average annual heating and cooling degree days, are presented in Table 1. The use of degree days offers context of the climate of the country and shows that the majority of the listed countries are predominantly in cold regions that require heating throughout most of the year. A wide variation in primary energy targets is evident, even for countries that have similar heating and cooling degree days (see Austria and Slovenia)

In comparison, the UAE has an average annual Heating Degree Days (HDD) and Cooling Degree Days (CDD) of 31 and 3564 [19], respectively, which emphasizes the high cooling requirement for buildings in the UAE. Whilst the UAE has a very high cooling load for buildings, it is comparable to the equivalent heating requirement for buildings in countries such as Austria and Denmark. Therefore, the nZEB targets set in these countries, whilst with a vastly different climate to the UAE, provides a good basis for the development of the nZEB target in the UAE (whilst noting that it is less energy intensive to heat buildings than cool them).

Table 1: nZEB targets of a few countries [20] with their annual average HDD and CDD (1982-2006) [19].

Countries	**Maximum primary Energy Target[a] (new buildings from 2020)/ kWh/m^{2}year**		**Average Annual[b]**	
	Residential	Non-residential	**HDD**	**CDD**
Austria	160	170	3181	212
Denmark	20	25	3653	45
Slovenia	50	70	3399	150
Cyprus	100	125	781	1196
UK[c]	44	-	2661	94

[a] For residential buildings: heating, cooling, domestic hot water, air conditioning energy loads considered. For non-residential buildings, lighting is also considered. For Austria, energy loads from appliances is included

[b] Based on Climate Design Data 2009 ASHARE Handbook with a temperature base of 18.3°C [19].

[c] Building assessed through a non-dimensional coefficient, comparing the buildings' primary energy use with a "reference" building with similar characteristics (e.g. building geometry).

Challenges and Opportunities to nZEB in the UAE

Building codes, standards and targets are often specific to each climate and are greatly influenced by each country's politics, economy, sustainability priorities and culture. The development and introduction of new building concepts, nZEBs in particular, should enable a smooth extension of the current building codes and be in line with the existing targets of the country. This was also highlighted in the Ecofys report developed for the European Commission in 2013, stating that the definition of nZEB must be aligned with the European targets of carbon dioxide emissions, energy efficiency and renewable energy [14]. Furthermore, it is common practice for government bodies and authorities to apply nZEBs first on government buildings, which can then later be mandated to the private building sector, as has been successfully implemented for the green building codes and standards in Dubai and Abu Dhabi.

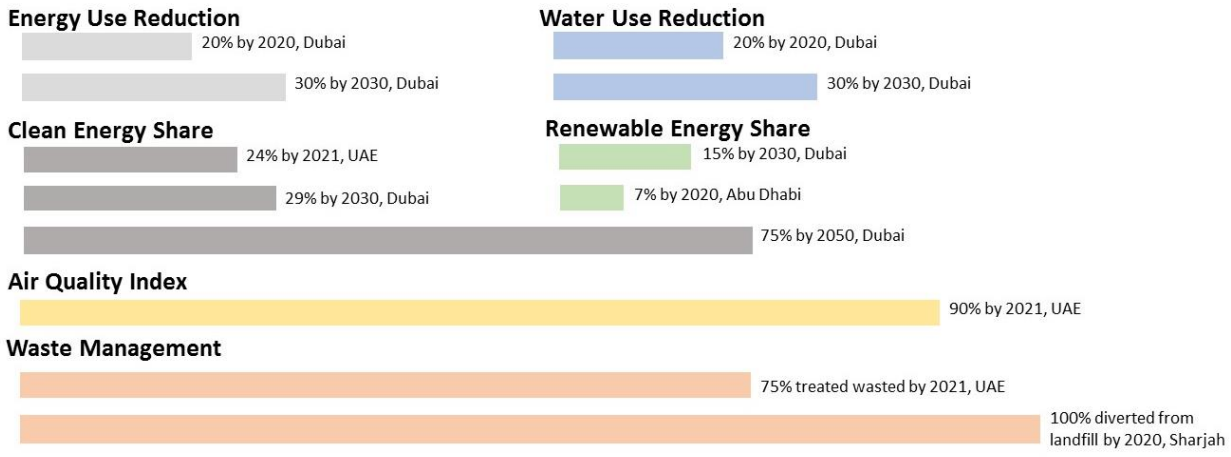
Sustainability and Building Strategies

The UAE government's strategies and initiatives reflect a clear sustainability vision with regards to ambitious well defined energy, water and sustainability targets. UAE Vision 2021, the Green Economy Strategy for Sustainable Development, Dubai Plan 2021, and Abu Dhabi Plan 2030 are the most prominent strategies that aim to strengthen sustainable built environments in the country. Some of the country's sustainability targets are summarized in Figure 3. It is clear that the UAE has put concerted focus on energy and water consumption as well as on waste management, air quality and clean energy generation. Dubai aims to reduce 30% of its energy and water consumption by 2030 and increase the share of clean energy to 75% by 2050.

To achieve the UAE's national targets and its global commitment at COP 21 of limiting global warming to less than 2°C, buildings, as a major consuming sector, will have to drastically improve their energy performance in terms of energy reduction, clean energy generation and reduction of greenhouse gas emissions and buildings' impacts on environment. By adopting the nZEB concept, benefits can be achieved across all of these areas, thus making it an attractive approach.

The UAE's government bodies have already enforced several building codes and rating systems including GBRS, Estidama PRS and Al Sa'fat rating systems. These building regulations have gone beyond mandating

Figure 3: Federal and local sustainability targets in the UAE.



energy and water management to embrace several green building principles, including, but not limited to, the improvement of indoor air quality and waste management. Therefore, it is necessary that a building in the UAE must achieve the minimum green building requirements as per each Emirate's regulations. However, for a building to be considered as a nZEB, it should not only comply with building regulations but should have improved energy performance.

A considerable portion of the building stock in the UAE have been constructed prior to the introduction of sustainable building codes and are inherently resource inefficient. To address this, several public and private initiatives were launched to engage in retrofit projects. Etihad ESCO, a Dubai Electricity and Water Authority (DEWA) venture, manages a retrofitting program for existing governmental buildings with the goal to create a viable performance contracting market for energy service companies in Dubai. Moreover, EmiratesGBC's Energy Efficiency Program also aims to support the retrofitting market in the UAE and can support in conjunction with the government strategies to facilitate the transition to nZEBs.

To better understand the performance of existing buildings, government authorities have also launched initiatives to benchmark buildings' energy performance. For instance, the Integrated Energy Intensity Mapping by DSCE can support future monitoring of the building stock in Dubai. DSCE has also partnered with EmiratesGBC to benchmark the energy performance of 100 buildings in three focus groups (hotels, malls and schools) as part of Dubai's commitment to Building Efficiency Accelerator, an initiative under the UN Program 'Sustainable Energy for All'. Benchmarks also aid in development of nZEBs as it allows target performances to be identified. Similarly, on the federal level, the 'Atmatah' Energy Database, developed by the UAE Ministry of Energy, will provide data to government users to track production and consumption trends of government buildings across the nation.

Energy Conservation and Generation

The market readiness for energy efficient solutions and renewable energy systems can be seen as a challenge when it comes to adopting nZEBs within a market.

The customer, end-user and operator awareness about cost-effectiveness of energy efficient buildings is still lacking. There is a misperception that higher investment costs are required for the construction of energy efficient buildings compared to conventional ones. However, it has been proven that energy efficient buildings, with up to 90% less primary energy for heating and cooling, can be constructed cost-effectively in most parts of the world [21].

The existing energy subsidies in the UAE create an additional barrier to the cost competitiveness of energy efficient systems and renewable energy sources. However, energy and water authorities on an Emirate level have increased the electricity tariffs in recent years in several Emirates including Abu Dhabi, Dubai and Sharjah. The increase in tariffs directs a consumers' attention to their energy spending and thereby raises awareness on the importance of reducing buildings' energy consumption.

Building occupant behavior is also major challenge to conserving energy in UAE buildings. Human behavior is even more critical when considering nZEBs; here the occupant must understand that the indoor environment and operation of nZEBs may not the same as in conventional buildings. For instance, behavior changes can account for anywhere from 5 to 30% energy savings in conventional buildings but can reach to more than 50% in very low energy buildings as demonstrated in the USA [22].

Existing codes and initiatives can help facilitate the adoption of renewable energy sources on the building's site, which have a pivotal role in nZEBs. For instance, the Shams Dubai program encourages households and building owners to install photovoltaic systems and connect them to the public grid under a net metering billing mechanism. However, in many cases relying on on-site renewable energy alone to achieve nZEBs may not be feasible, especially in high-rise buildings, where it can only cover a small share of the buildings' demand. In the US (Seattle, San Jose and Las Vegas), it was evaluated that achieving a net zero energy goal for a super high-rise office tower is impossible by just relying on on-site renewable energy generation [23]. To mitigate this space limitation challenge, district wide renewable energy systems or renewable energy credits (REC)[d] (or green tags) can facilitate the growth of nZEBs. In Dubai, the Dubai Carbon Centre of Excellence (DCCE) received the authorization from DSCE to document and issue RECs in the UAE as per the International REC Standard to become the sole issuer of RECs in the UAE. According to the DCCE, RECs will be available for purchase in Q3 2017 by both governmental and private sectors.

Passive Design in nZEBs

A common feature of nZEBs globally is an aggressive passive design regime. The Passive House Standard, established by the Passive House Institute, emphasizes on energy reduction and efficiency and requires that the primary energy demand (all energy loads) of a building should be less than 60 kWh/m^2/year [24]. Furthermore, it entails that optimal thermal comfort levels are maintained, whilst setting a maximum heating and cooling target of 15 kWh/m^2/year, through the use of insulation, improvement of airtightness and indoor air quality [24].

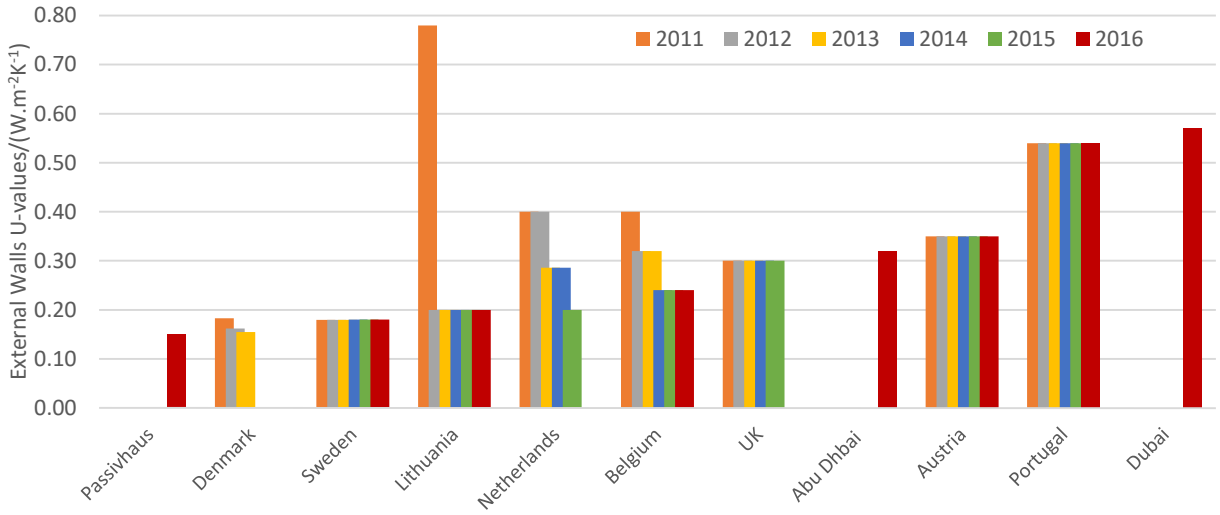
The passive house concept can be applied to all building types, budgets and climates; with a report by the Passive House Institute concluding that all renewable energy sources can be successfully integrated into a passive house [25], therefore providing an optimal model for Nearly Zero Energy Buildings (nZEBs). The concepts within the Passive House Standards, due to their strict thermal specifications, are very relevant to the UAE as cooling of buildings represents about 70% of the peak electricity loads in the GCC region [7], [26].

The U-value requirements for external walls for some European countries, collected through national sources by ZEBRA2020 [27], as well the minimum U-value requirement for Dubai and Abu Dhabi, based on PRS and DGBRS respectively, are shown in Figure 4. All the European countries mentioned in the graph, with the exception of Portugal, have set maximum primary energy targets for nZEBs [20]. A key observation of Figure 4 shows that some countries have made aggressive improvements to their external wall's thermal performance (see Lithuania, Netherlands and Belgium). Additionally, these countries, including Sweden, have U-value requirements close to the Passivhaus requirements (less than 0.2 W/m^{-2}K).

UAE's external wall U-value requirements, however, are higher than most of the European counties and are far from the Passivhaus external wall U-value requirements; with Abu Dhabi and Dubai being twice and thrice as high, respectively.

[d] One REC is equivalent to one megawatt-hour (MWh) of renewable electricity generated offsite and thus represents the environment benefit of 1 MWh of renewable energy generation. When one REC is purchased, it is proof that renewable energy is being generated on behalf of the buyer.

Figure 4: External wall U-values of some European countries. The Abu Dhabi, Dubai and Passivhaus external wall U-values requirements are also shown.



Examining Denmark's U-value requirement (0.15 W/m^{2}K – the same as the Passivhaus requirements) and their maximum primary energy targets for nZEBs (20 and 25 kWh/m^2/year for residential and non-residential; also shown in Table 1), shows that their aggressive nZEB targets are matched by their building requirements.

Case Studies

In order to support the definition of nZEB in the UAE, EmiratesGBC evaluated a number of case studies and obtained data on the performance of key projects in the UAE. Data was requested for key projects which included:

- project's general information (building typology, location, completion date and gross floor area).
- design and actual annual energy consumption of the participating projects including electricity, thermal energy and on-site fuel sources.
- annual energy costs including electricity, thermal energy and on-site fuel source.
- annual energy cost savings resulting from the installation of renewable energy systems on-site.

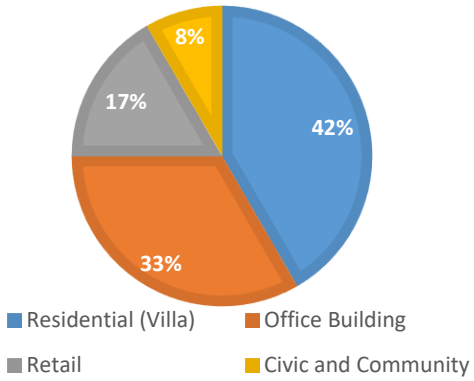
Overview of the participating properties

EmiratesGBC reached out to 25 companies and consultants in the UAE to obtain energy data of the best practices and low energy buildings. Out of the contacted companies, 12 volunteered to participate and submitted sets of consumption data. As shown on Figure 5, 75% of the submitted projects are residential villa buildings or office buildings. The data was provided directly by the participating properties, and have not been verified on site by EmiratesGBC. A preliminary review of the information, however, was conducted internally in order to identify discrepancies and errors to be corrected by the participating properties.

Of the participating properties, nine projects were selected by EmiratesGBC to be evaluated and analyzed for the nZEB Study. Five out of the nine projects were based in Abu Dhabi, with the remaining four projects being located in Dubai. The other three projects, which included two offices and one civic building, had high energy consumption (above 240 kWh/m^2/year) and thus were excluded from the analysis. 67% of the projects were completed and functioning as of June 2017.

The actual energy consumption data was not provided for most of the projects due to either confidentiality reasons or because some of the projects were still under construction at the time of submitting data. In other cases, the projects' consultants did not have access to the actual energy use data or were not allowed to disclose data and thus for the purposes of this study only the design energy consumption data provided has been analyzed. The design energy is based on energy models and includes all types of loads for the villa and office projects (regulated loads and appliances).

Figure 5: Breakdown of case studies according to building typology



Similarly, several projects did not provide the annual energy costs and annual energy savings data for the reasons mentioned above. As the actual energy consumption data was not provided for most of the projects, analysis of energy costs could not be done as it requires actual cost data. Therefore, energy costs have not been considered for this study.

All energy data provided in this study is based on site energy.

Energy Indicators of nZEB

Energy Use Intensity or Energy Use Index (EUI) per unit of floor area is internationally used to identify the building's energy performance level. According to the ASHRAE Standard 105-2007, it is defined as the annual energy used or calculated to be used by a building or building space per unit of gross floor area (in kWh/m^2). The annual energy consumption can be either accounted at the source or site and includes all the energy usage (electrical, thermal and onsite fuel) of the building. EUI is a useful and popular indicator, where most countries have defined their buildings' energy performance using it [28]. It has been also used in energy benchmarking of buildings when normalized for the climate, building use and occupancy.

The EUI has been used to set the source energy targets of nZEBs all around the world. For instance, under Article 9(3a) of the Directive 2010/31/EU, some of the Member states have already established numerical indicators of source EUIs for nZEBs, including France (110 kWh/m^2/year for air-conditioned offices), Latvia (95 kWh/m^2/year for residential buildings) and Sweden (55-130 kWh/m^2/year for residential buildings) [28]. These countries, however, have a different climate as compared to the UAE and thus their nZEBs energy indicators would not be suitable for evaluating nZEBs for this region. For hot and humid climates, it has been estimated that ultra-low energy buildings (or nZEBs) consume between 50 and 100 kWh primary energy/m^2/year for heating, cooling, dehumidification, ventilation and hot water [29]. Furthermore, simulations done by Ecofys and Wuppertal Institute evaluated the design EUI for cooling and dehumidification for an ultra-low energy building in Abu Dhabi, which reached approximately 70 kWh/m^2/year [30].

As discussed earlier, EUI's can either be calculated using source (primary) energy or using site energy. The site EUI does not differentiate between the primary energy sources and secondary energy sources, whereas the source EUI does. The source EUI, however, is complex to calculate as site-to-source conversion factors of grid-purchased electricity needs to be considered.

*Table 2: Table of parameters used for energy analysis. Parameters marked with * have been used for this study*

Parameter	Formula
EUI*	$\frac{Total\ Annual\ Energy\ Consumed\ (kWh)}{Gross\ Floor\ Area\ Area\ (m^2)}$
EPI*	$\frac{Total\ Annual\ Renewable\ Energy\ Produced\ onsite\ (kWh)}{Gross\ Floor\ Area\ (m^2)}$
RE*	$\frac{EPI}{EUI}$
nEUI*	$\frac{Net\ Energy\ Consumed\ Onsite\ from\ Nonrenewable\ Energy\ Resources\ (kWh)}{Gross\ Floor\ Area\ (m2)} = EUI - EPI$

The UAE currently generates most of its electricity using natural gas-fired generation plants [31], [32]. This will adjust in the future as the UAE aims to diversify its energy mix to include nuclear, renewable and clean coal [32]. At the building level in the UAE, the building user does not have choices with respect to the source of grid primary energy they connect to and therefore it is considered appropriate to use site level EUI as the metric in defining nZEB in the UAE.

Another parameter considered within this study is the Energy Produced Index (EPI), which is the total renewable energy produced on-site (in kWh) per unit of floor area (in m^2). It evaluates both electrical and thermal renewable energy produced on-site and supports in accessing the net overall energy consumption of the building from the public grid or from nonrenewable energy sources (net Energy Use Index – nEUI). The ratio of EPI to EUI, defined as the Renewable Energy Fraction (RE), was calculated to support classifying the case studies as Nearly Zero, Net Zero or Net Plus buildings.

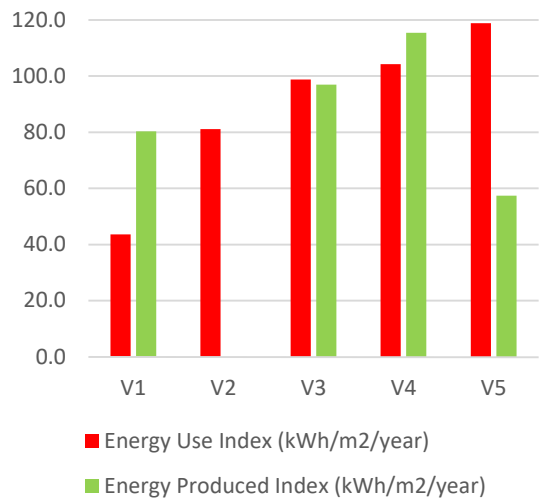
Energy Analysis and Results

Different building typologies have different energy requirements and are thus compared separately to allow proper energy assessment and benchmarking. Within this study, residential villa typologies are denoted with V; Office typologies are denoted as O; whilst Retail typologies are denoted with R. As there are no current frameworks or energy performance regulations for nZEBs in the UAE, each project has been analyzed based on the performance of the other comparable case studies and the existing benchmarks found in literature.

Figure 6 shows the design energy indicators (EUI and EPI) of the different villa projects submitted. As observed, the values of the EUI ranged between 44 and 119 kWh/m^2/year, whilst the median EUI was 98.8 kWh/m^2/year. On the other hand, the EPI of the villa projects ranged between 0 and 115.4 kWh/m^2/year, whilst the median EPI was 80.4 kWh/m^2/year. It can be also seen that the percentage of renewable energy produced on-site varies between the villa projects as V2 does not produce any renewable energy on-site while V1 produces 184% of its consumption. The median renewable energy percentage of the five villa projects is 98%. Accordingly, it is observed that several concepts of ZEBs can be seen within these case studies.

- V1 and V4 can be seen as Net Plus Site Energy Buildings as these projects generate more energy than they consume on annual basis with a RE ratio of 184% and 111%, respectively.

Figure 6: Energy Data of the Residential Villa Projects



- ❖ V3 is a Net Zero Site Energy Building as it produces nearly the same amount of energy as it consumes with a RE ratio of 98%.
- ❖ V2 is a highly energy efficient building with no RE production on-site.
- ❖ V5 can be considered as a Nearly Zero Site Energy Buildings.

It should also be noted that even though only the design energy data was used for the analysis, V2 reported a lower 11.1% actual energy usage in 2014, making their actual site EUI 72 kWh/m^2/year. This provides some validation of the design data but it is noted that the study would be further strengthened with measured consumption data validation.

Figure 7 shows the EUI and EPI of the office building typologies. It is observed that both selected case studies, O1 and O2, have relatively the same EUI (90.6 and 92.1 kWh/m^2/year, respectively). The RE ratio of O1 is 5%, while O2 produces 11% of its energy consumption from renewable energy. Given how low the EUI and nEUI (85.7 and 82.4 kWh/m^2/year for O1 and O2, respectively) is for each of these case studies, and how it compares to some of the current nZEB offices around the world, as per case studies reported by IEA Joint SHC Joint Task 40 [33], O1 and O2 can be considered as Nearly Zero Site Energy Buildings.

Figure 7: Energy Data of the Office Projects

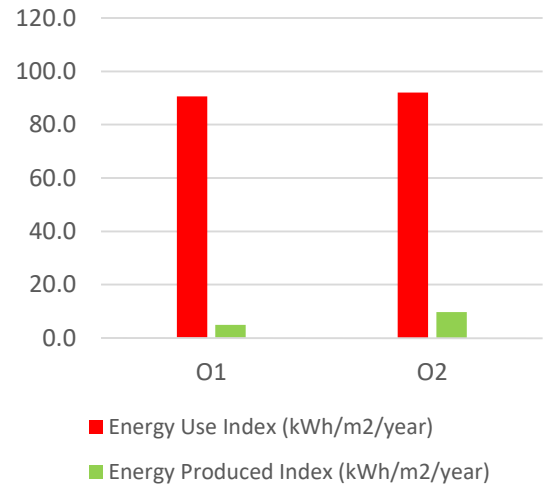
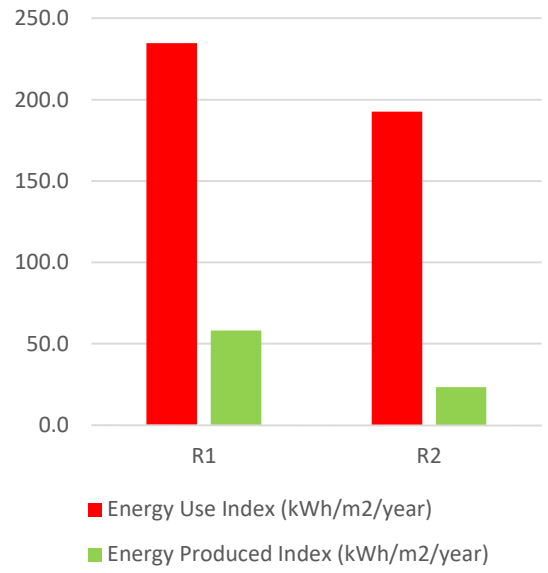


Figure 8 shows the energy data of the retail projects, R1 and R2. R1 has an EUI of 234.8 kWh/m^2/year but excluded the gas and receptacle loads (plug loads, elevators and IT rooms) and therefore cannot be directly compared to R2, which has an EUI of 192.6 kWh/m^2/year. Furthermore, R1 has a RE ratio 25% whilst R2 has a RE ratio of 12%; Currently, there are few examples of nZEB shopping/retail typologies, with most nZEB strategies being implemented on residential and office typologies. In Illinois, US, a Net Zero Retail Store was completed in 2013, and in 2014, the actual nEUI was measured to be 58.7 kWh/m^2/year [34]. In Norway, however, a nZEB shopping mall has an EUI of 86 kWh/m^2/year, whereas, in Finland, an energy efficient shopping mall was designed to have to have an EUI of 123 kWh/m^2/year, according to case studies done by Skanska [35]. It can be seen that there is a wide range of EUIs reported for nZEB retail/shopping centers around the world and therefore more case studies are needed to build capacity and create benchmarks. Thus it can be reported that both R1 and R2 are energy efficient retail buildings with a good onsite renewable energy contribution.

Figure 8: Energy Data for the Retail Projects[e]



Case Study Summary and Conclusions

To support this Report's objective to build capacity and advise policy makers about the achievable targets of nZEBs in the UAE, EmiratesGBC reached out to 25 companies to obtain energy data on best practice of low energy buildings in the UAE. Energy data of nine selected case studies were analyzed to better understand the potential achievable targets of nZEBs in the UAE. The selected case studies demonstrated that nZEBs are feasible in the UAE despite the harsh climate prevalent in the region.

Key results from the case studies show:

- Several concepts including Nearly Zero, Net Zero and Net Plus Energy Residential and Office Buildings already exist or are under construction in the UAE.
- Nearly all the chosen case studies have on-site renewable energy generation.
- The five residential villas have an Energy Use Intensity (EUI) ranging from 44 to 119 kWh/m^2/year.
- The Renewable Energy Fraction (Energy Produced Index to Energy Use Intensity ratio) of the villa projects ranged from 0% to 184%.
- The two Office nZEBs have EUI of 90.6 and 92.1 kWh/m^2/year with RE ratios of 5% and 11%.

With respect to retail, it was difficult to evaluate the energy performance level of these projects due to the absence of international standards and benchmarks. Hence, the retail projects R1 and R2 were classified as energy efficient buildings until further research is available for retail buildings specifically.

Almost all the case studies, other than V2, produce renewable energy on-site, which is important to offset the energy consumption in nZEBs. The five villa projects have demonstrated a high renewable energy contribution with a median of 98%. It is clear that any future nZEBs development in the UAE should include renewable energy generation as part of its strategy.

The analysis of the case studies come with limitations because only the design data was considered and it is unknown how the actual energy usage compares to the design. Furthermore, as mentioned previously, building occupant behavior can play a significant role in the energy consumption of nZEBs, as the indoor environment and operation of nZEBs are not the same as in conventional buildings. Thus it becomes important to re-evaluate the case studies using actual energy data.

[e] *R1 and R2 are connected to district cooling networks. The average efficiency of district cooling systems specified by the Dubai Regulatory and Supervisory Bureau's market and efficiency cooling study* [39] *was used to convert the chilled water consumption in R1 and R2 to electrical energy.*

Stakeholder Survey

It has been observed that there is still ambiguity to the applicability of Nearly Zero Energy Buildings (nZEBs) in the UAE. Stakeholders hold varying concerns and opinions in relation to nZEBs, which can impact the definition of a nZEB and can dictate how the building will be designed and subsequently assessed. The industry's understanding of nZEBs has an impact on market readiness for a nZEB strategy in the UAE, which requires a close examination. Given that the UAE aims to strengthen its position as a leader in sustainability of the built environment, as demonstrated by the national and emirate level targets and plans, as well as the implementation of green building codes and rating systems, it is critical that all industry stakeholders are aligned on the concept and definition of nZEBs.

In order to measure the market perception for nZEBs and identify factors and parameters that need to be addressed in the UAE's definition of nZEBs, EmiratesGBC conducted a nZEB survey in May 2017 to evaluate the position and views of different stakeholders including government, consultants and academia.

Methodology

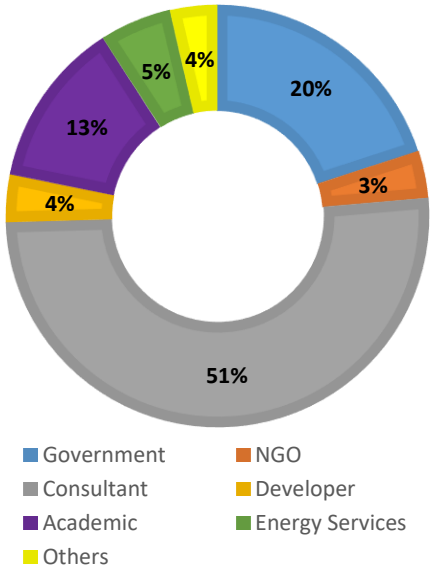
A cross-sectional analysis using an online questionnaire was used for the nZEB survey. The questionnaire was based on the review of different Zero Energy Building concepts used around the world and was designed so that the market readiness and the barriers for nZEBs could be assessed.

EmiratesGBC approached key stakeholders across the industry to complete the online questionnaire. The list of building experts was selected internally by EmiratesGBC on the basis of the sector they worked in, their role in the sector and their overall experience within the region. The survey was sent through an online invitation to 100 different building experts and leaders in the country in early May 2017, with the deadline of 25 May 2017.

Results

The response rate, out of the 100 contacted building professionals, was 55%. By sector, of the 55 respondents, the majority were consultants (28 respondents) followed by government (11 respondents) and academia (7 respondents). The full breakdown of the participating sectors is shown in Figure 9, where it can be seen that the private sector (all categories excluding government) comprise 80% of the questionnaire respondents.

Figure 9: Sector breakdown of participating respondents.



The UAE government is well regarded in its pursuit to improve energy efficiency of the built environment, where over three quarters of survey respondents ranked the UAE government as ambitious or highly ambitious, illustrated in Figure 10. These results were consistent across all respondent sectors, particularly among the private sector. The respondents also agree, as shown in Figure 11, that the UAE market is ready for a nZEB strategy with 27% and 44% of the respondents answering that it should

be implemented by 2020 and 2030, respectively. These results demonstrate a substantial potential for a successful launch and implementation of a nZEB strategy in the UAE in the near future.

Figure 10: Questionnaire responses to how respondents rank UAE's ambition to improve the energy efficiency of the built environment.

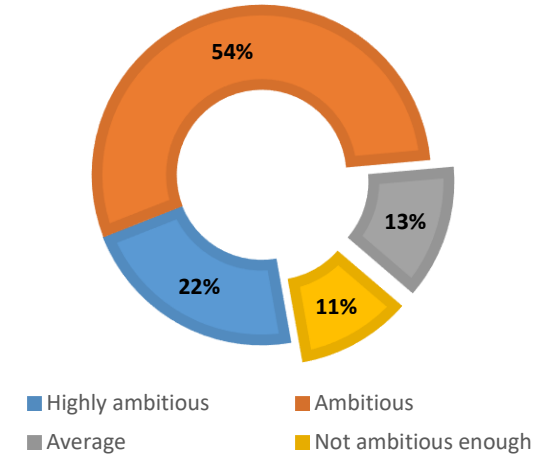
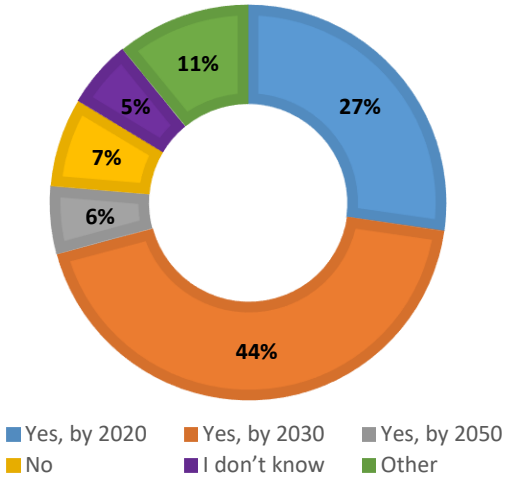


Figure 11: Questionnaire responses to whether the UAE is ready for a nZEB strategy and its implementation.



Building Typology

Building typologies differ by operational characteristics and thus have different energy consumption needs and patterns. This places importance on selecting which building typology is best to implement a nZEB strategy as it could potentially affect the nZEBs definition and its EUI targets. For instance, low-rise residential buildings (villas) have different energy consumption and roof space available for the installation of solar panels as compared to offices or high-rise buildings. In fact, most EU Member States have expressly defined numerical targets for nZEBs differently for residential and non-residential buildings [28].

It was indicated, through 49% of survey responses, that government buildings are the best building typology to implement a nZEB strategy in the UAE (see Figure 12). As previously mentioned, both Abu Dhabi and Dubai have respectively implemented the Estidama Pearl Rating System and Dubai Green Building Regulations and Specifications on governmental buildings before mandating their expansion to private buildings, thereby supporting this result. The survey feedback also indicates that apart from government buildings, residential villas (24%) and low and medium buildings (11%) are suitable typologies for implementation.

There are over 500 high rise buildings (above ten floors) in Dubai alone [36] and so it becomes essential to determine whether a nZEB strategy can be applied to them. As seen from Figure 13, the respondents were divided in their views with 47% agreeing that a nZEB strategy can be applied to high-rise buildings whilst 40% disagreed, with the remaining 13% being unsure. Therefore, it can be concluded there is no clear agreement of whether a high-rise building in the UAE can meet a nZEB definition. While the questionnaire results do not offer an explanation, it could be speculated that 40% of respondents who disagreed, answered due to the space limitations of high rise buildings.

Figure 12: Questionnaire responses to the best building typology to implement a nZEB strategy

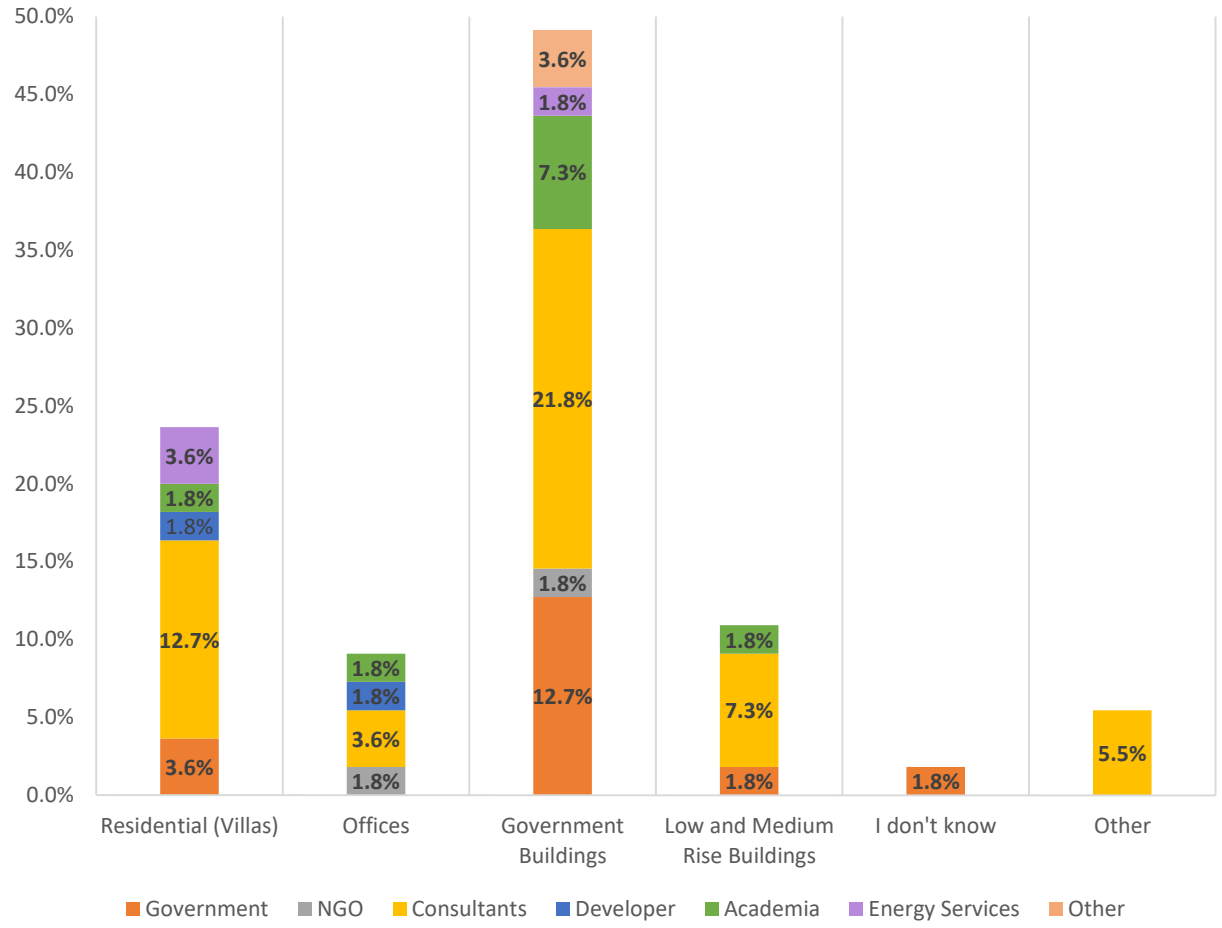
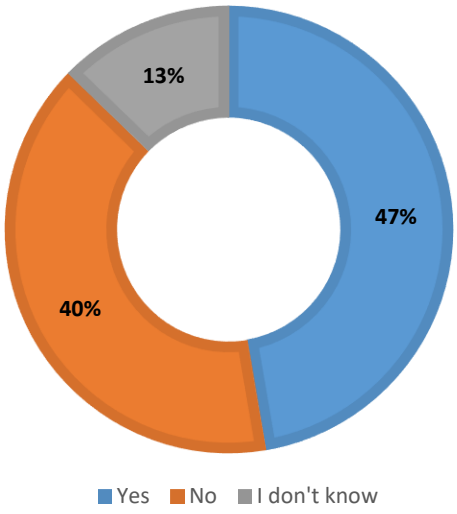


Figure 13: Questionnaire responses to whether the Nearly Zero Energy Concept can be achieved by high-rise buildings

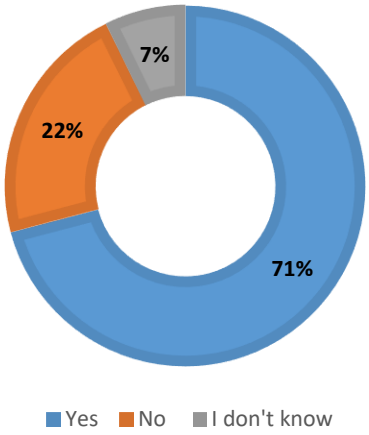


Energy Balance

As stated previously in the Defining Zero and the Case Study sections, the energy balance of a building can be assessed using either source energy or using site energy. It was noted that source energy balance is the most equitable balance and is used in both Europe and U.S. The survey results further emphasize the importance of using source energy for the assessment of nZEBs. As shown in Figure 14, 71% of the responses agree that source energy should be incorporated in the definition of a nZEB in the UAE, with 22% disagreeing and 7% being uncertain. In contrast to the survey results, the site energy balance was used for the analysis of the selected projects in this study. If source energy is to be used, then standard source-site conversion ratios are needed.

For the UAE, detailed energy reports accounting for losses, similar to the US Energy Information Administration Annual Energy Review, should be available to aid in establishing national source-site conversion ratios.

Figure 14: Questionnaire responses to whether source energy should be applied when defining a nZEBs in the UAE



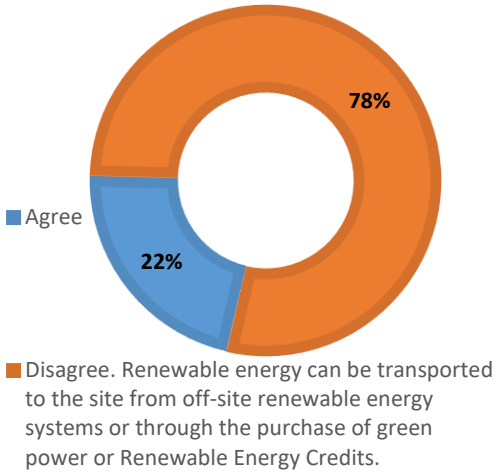
Renewable Energy

As shown in Figure 15, 78% of the respondents, answered that nZEBs in the UAE do not necessarily need on-site renewable energy generation. Instead, nZEBs in the UAE can purchase RECs or use renewable energy transported to the site from off-site renewable energy systems through purchase of 'green power'. This makes it feasible to be implemented for buildings with space limitations.

These results are contrasted with nZEBs concepts in other regions, which consider that a reasonable portion of the energy balance should be harnessed from renewable energy sources on-site or nearby [28], [37]. For instance, a study of existing nZEBs in 17 different European countries showed that 81% of the nZEB building stock have some form of on-site renewable energy generation [6].

In Canada, however, the Zero Carbon Building Standard offers more flexibility as it states that zero carbon balance can be achieved using either on-site or off-site sources of renewable energy, but also adds that new buildings must generate at least five percent of its total energy consumption on-site [37]. Therefore, to support future development of nZEB concepts in the UAE, it becomes necessary to allow flexibility for the source of renewable energy generation.

Figure 15: Questionnaire responses to whether renewable energy must be generated on-site for nZEBs in the UAE



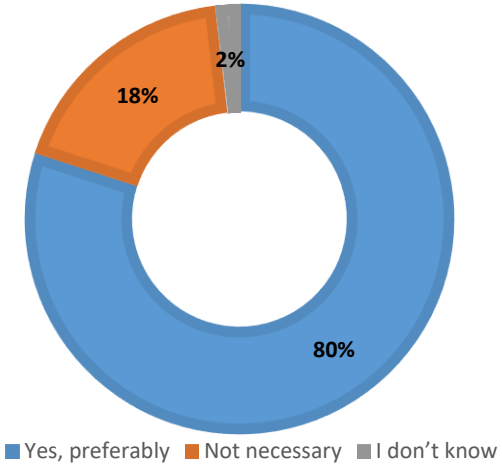
It should be noted, however, that while the use of RECs be considered to contribute to the nZEB equation for buildings in the UAE, it should be government regulated RECs to ensure that the REC's relate to actual renewable energy generation within the UAE.

Emissions

As previously discussed, Nearly Zero concepts can focus either on Energy, as is the case for EU Member States, or on Carbon Emissions, as outlined by the World Green Building Council's Advancing Net Zero initiative. Although this study has primarily focused on Nearly Zero Energy, 80% of the respondents, as shown in Figure 16, answered that nZEBs in the UAE should also include targets for building emissions. This is concordant with global trends, where several countries such as Austria, UK and Canada [28], [37], have also considered

targets for building emissions in response to climate change agreements.

Figure 16: Questionnaire responses whether building emission targets should be included for nZEBs in the UAE

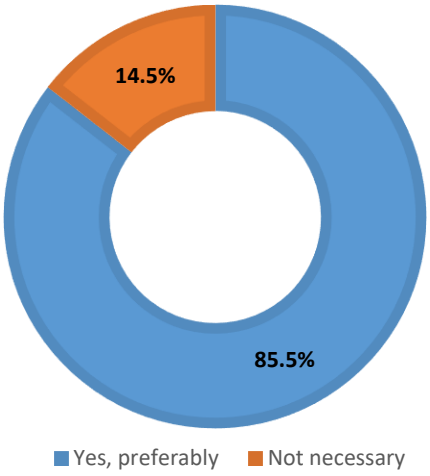


For building emission targets to be incorporated for nZEBs in the UAE, the Greenhouse Gas (GHG) emissions from buildings must first be quantified. A GHG inventory methodology, such as the GHG Protocol Corporate Accounting and Reporting Standard developed by the World Resources Institute and World Business Council for Sustainable Development, can be adopted by the UAE to standardize the methodology for quantifying GHG emissions similar to how it is implemented in the US and Canada.

Cost

One of the primary barriers to the adoption of nZEBs and to energy efficient buildings is the misconception that nZEB buildings require higher investment costs. This is evident from the 86% of respondents (shown in Figure 17) that believe a nZEB strategy in the UAE should be cost-effective. This was further evidenced by respondents who commented that costs of financing nZEBs is a challenge and is similar to professionals' opinions from European survey findings about nZEBs, where the investment costs were the single largest criteria regarding the selection of technologies for nZEBs [38].

Figure 17: Questionnaire responses to whether a cost-effective approach should be applied to nZEBs in the UAE



This concept of cost-effectiveness has been mandated in Europe under the Directive 2010/31/EU, as previously outlined; and it was shown by Zebra2020 that the greatest energy and lifetime cost savings could be achieved from deeper renovations of existing buildings to nZEB level (95% energy savings), even though the initial investment is higher as compared to renovations to lower levels (15-45% energy savings) [38]. Examination of these findings highlight that target costs can be used as a key performance indicator for future developments of nZEBs in the UAE.

Energy Use Intensity (EUI)

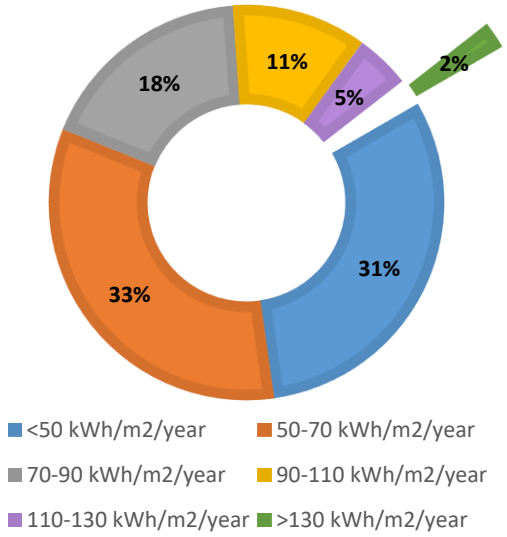
As mentioned in previous sections of this report, the EUI allows the energy performance of buildings to be measured and can also be used as a metric for evaluation of nZEBs, as seen in many European Member States such as France and Sweden [28].

As illustrated in Figure 18, among the responses who specified an EUI target for nZEBs in the UAE, nearly all of the respondents answered that the EUI should be below 130 kWh/m^2/year. This is consistent with the findings from the case studies, where it was observed that both

residential (villa) and office projects have an EUI below 130 kWh/m^2/year. It is not consistent, however, with the majority responses that answered EUIs for nZEBs in the UAE should be below 50 kWh/m^2/year (31%) or between 50-70 kWh/m^2/year (33%).

The other responses, which did not specify an EUI target, commented that the energy consumption for nZEBs cannot be recommended as it depends on current energy benchmarks, building typology and the contribution from renewable energy systems. Examination of the distribution of the answers shown in Figure 18, and the respondents' comments indicates that there is no clear agreement for a suitable nZEB EUI range in the UAE.

Figure 18: Questionnaire responses to energy consumption targets for nZEBs in UAE

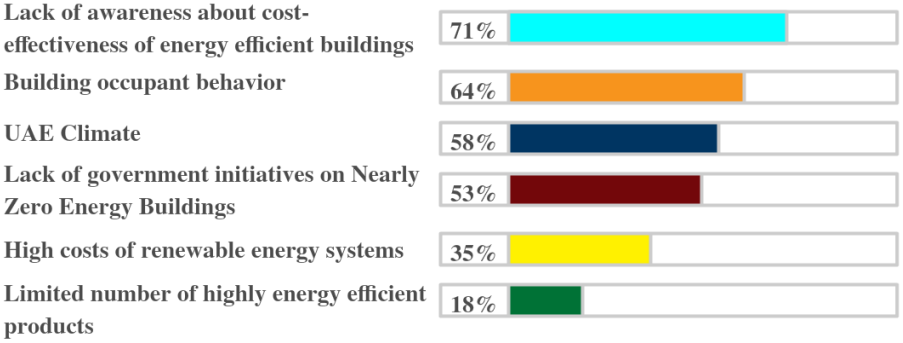


Challenges

Figure 19 shows that lack of awareness of the cost-effectiveness of energy efficient buildings (71% of total responses), building occupant behavior (64% of total responses), the UAE climate (58% of total responses) and the lack of government initiatives (53% of total responses) rank among the top perceived challenges to the adoption and spread of nZEBs in the UAE.

The questionnaire respondents also noted that understanding the barriers to energy and water savings is important and evaluating energy consumption through more effective metering systems would help. This runs in parallel to other statements, where it was commented that the building efficiency and the intensity demands for energy should be understood, whilst others recommended an energy performance rating for buildings. Furthermore, some of the respondents offered additional barriers that were not mentioned in the survey, which included a lack of knowledge for financing renewable energy and the quality of construction execution.

Figure 19: Survey results to the challenges for the adoption and spread of Nearly Zero Energy Buildings in the UAE



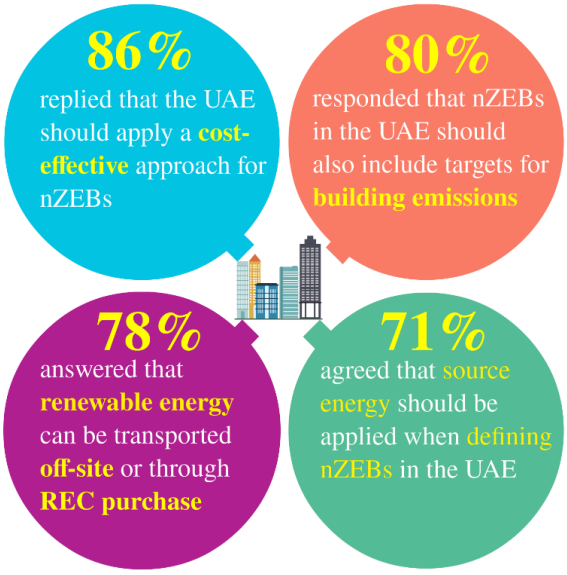
Survey Summary and Recommendations

The survey results provided key insights, illustrated in Figure 20, which can aid in the definition of nZEBs in the UAE. For instance, it was observed that respondents could not agree whether high-rise buildings in the UAE could perform as nZEBs, potentially a response due to space limitation. Subsequently in the renewable energy section, the results showed that off-site renewable energy generation could be used for nZEBs in the UAE, which would potentially address issues with buildings with space limitations. It can be recommended based on the results of the survey, that nZEBs in the UAE should allow for both on-site and off-site renewable sources. This will allow future developments of nZEBs in the UAE to be flexible in their design and construction.

The questionnaire responses also indicated:

- there is potential for successful implementation of a nZEB strategy in the UAE as determined from the 79% response that the UAE market is ready for nZEBs.
- an upper limit EUI of 130 kWh/m^2/year for nZEBs in the UAE (98% of responses who suggested an EUI target), with 82% further identifying that the EUI should be below 90 kWh/m^2/year.
- nZEBs in the UAE should be cost effective (86% of total response).
- nZEBs should include targets for building emissions (80% of total response).
- source energy should be used to evaluate nZEBs in the UAE (71% of total response).
- governmental buildings are the best typologies to implement a nZEB strategy (41% of total response); followed by residential villas (24%).

Figure 20: Key results from the nZEB survey for the UAE



Inspection of the comments made for that question, as well those made at the end of the questionnaire, showed that current EUIs of existing buildings in the UAE are not clearly understood and steps should be pursued to make them apparent. Based on this, it can be recommended that establishing energy benchmarks would allow informed building specific EUI targets for nZEBs in the UAE to be suggested.

Findings

This report found that there is a global shift in the spread and development of nearly or net zero buildings, with many European member states, as well as the US and Australia, declaring that all buildings in their respective countries are to be net zero in the future. It was also found, however, that there is a lack of an international standardized definition of a Zero Energy Building (ZEB), as some countries focus on energy and cost-optimality while others place emphasis on carbon emissions. Furthermore, there is an absence of unified building performance indicators. The only common factor identified across all zero building definitions was renewable energy generation.

By evaluating the different concepts of zero energy buildings, it was found that adoption of these concepts can serve to stimulate the market to focus on energy reductions within the built environment, as evolution to a Nearly Zero Energy Building (nZEB) market includes embracing a passive building design, increasing buildings' energy efficiencies and generating renewable energy to balance the energy consumption. In the UAE, examining traditional Arabic architecture can aid in incorporating passive-energy efficient building designs and low-cost lifecycle measures into nZEBs.

National regulations, policies and strategies are significant as they push for higher energy efficiencies, thereby easing the transition into nearly zero buildings. This is evident when examining zero building concepts around the world, where progress to nZEBs within the country comes from the policies outlined by national government, as seen in Europe. Regionally, the UAE is dedicated to being a leader in sustainability within the built environment, and a number of the initiatives and strategies launched in the UAE that showcase UAE's commitment were referenced in this report. By examining the current trends in the UAE, it was found that development of nZEBs should be facilitated by a smooth extension of current existing building codes and regulations so that nZEBs in the UAE adhere to the minimum building requirements as per each Emirate's regulation.

Although the UAE has a hot and humid climate, the projects presented in the Case Studies section above demonstrated several of the nZEB concepts already exist in the UAE. The Energy Use Intensity (EUI) ranged from 44 to 119 kWh/m^2/year for the villa projects; 90.6 to 92.1 kWh/m^2/year for the office projects. The EUIs for the projects aligned well with the survey results, whereby nearly all of the respondents answered that the EUI for nZEBs in the UAE should be below 130 kWh/m^2/year. Concordant with existing European nZEB buildings, most of the case studies generated renewable energy on-site with a median Renewable Energy (RE) Fraction of 98% for the villa projects. The case studies revealed that nZEBs are not only possible in the UAE but also showed that they can be designed to be net positive, whereby it is possible to generate energy from the buildings.

The market position was examined through the use of a nZEB survey, where it was seen that there is substantial potential for the implementation of a nZEB strategy in the UAE. The survey also highlighted challenges and barriers to the adoption of nZEBs in the UAE, with the lack of awareness about cost-effectiveness of energy efficient buildings cited as the biggest challenge. The survey provided key insights into the different factors that should be addressed in the development of a nZEB strategy in the UAE, which included an upper limit EUI of 130 kWh/m^2/year (98% of responses who suggested an EUI target) with 82% recommending EUI should be below 90 kWh/m^2/year, cost-effectiveness (86% of total response), building emission factors (80% of total response), off-site renewable energy generation or the use of RECs (78% of

total response), the use of source EUI as a metric of evaluation (71% of total response), and best building typology to implement a nZEB strategy (governmental buildings with 44% of total response).

Based on the findings of the report, EmiratesGBC recommends the following definition for residences and offices in the UAE:

A Nearly Zero Energy Building (nZEB) in the UAE can be defined as a highly energy efficient building with a site EUI less than 90 kWh/m^2/year and covers a significant portion of its annual energy use by renewable energy sources produced on-site or off-site.

An ambitious site EUI target for nZEBs in the UAE is set as it runs in conjunction with UAE's targets for energy reduction. This definition, however, is only conclusive from the results of the report and therefore is limited in its scope as:

- There was a limited number of evaluated case studies and survey respondents.
- Even though source EUI allows a better assessment of building energy performance and was recommended by over two-thirds of the survey respondents, it cannot be included in the definition as only design site EUI was reported for the case studies.
- The amount of renewable energy that should be generated by a nZEB in UAE was not investigated and therefore cannot be recommended.

In setting this target, EmiratesGBC would recommend that the definition is reviewed with key stakeholders in the public and private sector, through an appropriate stakeholder consultation process, to agree on the definition.

This definition is not static and should be reviewed periodically, as more nZEBs are developed in the UAE, to not only include the factors mentioned above, but also other factors and targets which were highlighted previously such as building emission targets and cost-effectiveness.

Next Steps

The UAE is pursuing higher energy efficiencies within the built environment and it is a natural next step to start development of Nearly Zero Energy Buildings (nZEBs). The UAE government can build upon the UAE Vision 2021, Dubai Plan 2021, Abu Dhabi Plan 2030 and the current building regulations to develop long term goals, which can aim to a majority of nearly zero energy buildings in the country, in line with current global pursuits.

As there is an absence of unified building performance indicators, this report references and recommends the use of standard key building performance indicators for the evaluation of nZEBs in the UAE, which include Energy Use Intensity (EUI), Energy Cost Index (ECI), and Renewable Energy Fraction (RE). This report should serve to assist the development of a national strategy for a market transition to nZEB, which can outline UAE's building environment for upcoming years. A nZEB strategy in the UAE should encompass assessment, monitoring and reporting policies and be robust enough to outline both short and long-term goals to enable a smooth transition to nZEBs. It is also recommended that any nZEB strategy developed by the UAE should be reviewed periodically as newer technologies are consistently being developed, which can further push the energy performance of both existing and newly constructed buildings.

The government can overcome challenges to the development of nZEBs in the UAE, such as the lack of awareness of the cost-effectiveness of energy efficient buildings, through nationwide awareness and educational campaigns, which showcase the benefits of nZEBs, as well as increased demonstrations of nZEBs projects, such as those presented in the Case Studies section. NGOs can be influential in raising awareness of the populace, which can also be effective in changing building occupant behavior.

Through the analysis of the case studies and survey comments received, it was recognized that there is a lack of established benchmarks in the UAE. It is recommended that energy benchmarks be established in the UAE to enable buildings' energy characteristics to be evaluated, guide stakeholders in reducing their energy consumption levels, and serve as a reference point for nZEB EUI targets. Furthermore, with the use of benchmarks, building energy labeling schemes can also be implemented, which would illustrate the benefits of an energy efficient building to investors, building owners, tenants and the general public.

The private sector, and the consulting sector in particular, can be pivotal in aiding the government through its technical expertise by supporting the development of nZEBs in the UAE, and by designing, constructing and operating nZEBs effectively to ensure that nearly zero energy is achieved throughout the entire lifecycle of a building. Academia can also be vital in this process with research into cost-optimality of nZEBs specific to the region as well as technical papers regarding nZEB characteristics such as building envelopes, integration and optimization of renewable energy technologies, lighting and HVAC systems.

Additionally, stakeholders involved in the entire chain of a building lifecycle must take an active role to advance UAE's ambition of becoming a global leader in sustainability. Businesses and investors should commit to investing in nZEBs in UAE to broaden their market portfolio and thereby increase their asset values. Incentivizing nZEB projects can also aid market transition to higher energy performances. Developers can actively build more nZEB projects to stay ahead of building codes and regulations, earn a good return on investment, and attract more

environmentally focused clientele who will be willing to invest higher to support a sustainable future.

The Emirates Green Building Council is committed to advancing green building principles for protecting the environment and ensuring sustainability in the UAE. This report is written to demonstrate the benefits of Zero Energy Buildings and how they can be implemented in the UAE. To this extent, EmiratesGBC realizes the potential of Nearly Zero Energy Buildings and advocates a combination of both public and private efforts to identify the most effective design and construction solutions, which can lead to the development of a nZEB strategy in the UAE.

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