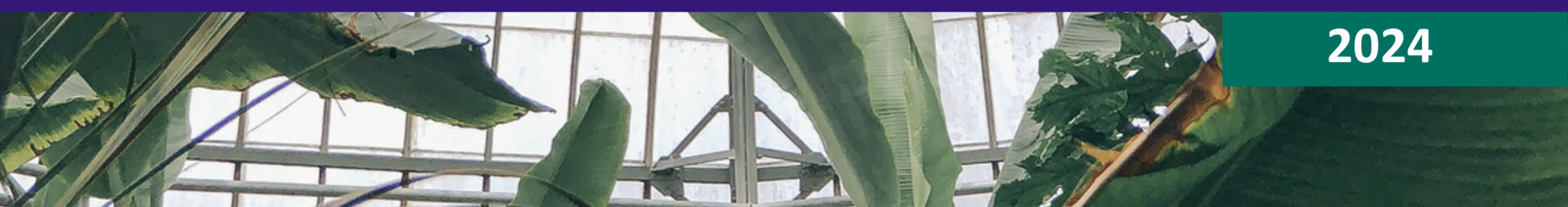
Emirates Green Building Council

“**Optimizing Workplace Well-being:** A Unified Approach to Green Building Standards and Office Comfort”



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About Emirates Green Building Council

Emirates Green Building Council (EmiratesGBC) 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 to meet, discuss, interact, and exchange ground-breaking ideas which helps 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.

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Acknowledgments

We extend our heartfelt gratitude to the distinguished speakers whose insights illuminated our focus day, Health, Wellbeing, and Productivity in Green offices, Breaking the Space to Factors. Their expertise enriched the exploration of diverse aspects of the indoor environment. Below is a mention of the esteemed speakers whose participation has been integral to the comprehensive analysis presented in this paper, capturing the essence of collaborative efforts towards sustainable and harmonious interior spaces.

Factor 1: Thermal Comfort
Presenter: Jason Hird, Head of Technical Development, Saint Gobain

Factor 2: Indoor Air Quality and Ventilation
Moderator: Patrick Barry, MEP Director, Meinhardt
Panelists:
Angie Lorena Sanchez Pina, Air Quality Specialist, Green Development & Environment Affairs, MOCCAE
Rohan Chopra, Regional Director, Sustainability – MEA, Johnson Controls
Rila Khairun, Technical Support Engineer, Building Doctor
Samer Alhamdan, Senior Architect, Project Manager, Dar Al-Handasah (Shair and Partners)

Factor 3: Acoustics
Presenter: Ali Aurangzeb, Senior Acoustic Consultant, WSP

Factor 4: Daylighting
Moderator: Myriam Hakim, Head of Specification, Saint Gobain
Panelists:
Surabhi Saran, Sustainability professional, LEED AP, Energy Efficiency, Outdoor thermal comfort, Specialist Consulting, AESG
Jana Gharazeddine, Architect at Gensler, LEED® Green Associate, Gensler
Dina Abu Taah, Sustainability Engineer, LEED AP Dewan Architects and Engineers
Samer Al-Saadi, Senior Sales Engineer, Siemens

Factor 5: Biophilia
Presenter: Julija Gruden, Senior Technical Sales and Specifications Manager, Knauf Insulation, Urbanscape Green Solutions

Compiling the Factors, Building the Business Case for Health Wellbeing and Productivity in Green Offices
Moderator: Alicia Dauth, Senior Associate Environmental Consultant, AESG
Panelists:
Ragini Kalapatapu, ESG Lead, Egis Middle East and South Asia
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Introduction

The population is set to grow by 50% by the end of this century, which puts extreme stress on the building industry due to rising population and climate change. Moreover, people are spending about 90% of their time indoors which sheds light on the importance of cities and spaces; they need to be designed with a positive impact on people, communities, health and wellbeing, social justice, and equity [1]. Despite the surge in attention towards mentioning well-being in the built environment, there is still a lot of doubt about how to design and measure it. A clear interdisciplinary understanding of the relationship between municipality well-being and the conception, operation, maintenance, and renovation of the spaces we occupy is needed to define well-being, which is often associated with happiness, comfort, and health. Traditionally, research on comfortable and healthy buildings has been confined to preventing discomfort and dissatisfaction. Moreover, elements of the indoor environment (IE) have been limited to visual, acoustic, thermal, and olfactory qualities.

> ***However, it is important to note that the absence of well-being does not necessarily mean well-being [1].***

In the last few years, LEED and BREEAM, have expanded their assessment to include the direct and indirect impact of building on occupants beyond IEQ. LEED added impact categories where wellbeing should "promote the health of the occupants and users, the surrounding community, or the supply chain. Likewise, BREEAM added points related to social and economic well-being, transportation and movement, safety, and security. Furthermore, the WELL certification scheme also goes beyond IEQ, considering the mind, movement, and nourishment [1]. Similarly, the Dubai Land Department in collaboration with WELL, has introduced a well-being certification to improve sustainability and enhance investors' trust [2].

Moreover, World GBC has developed the **Better Places for People Program** to support the transition towards healthy, equitable, and resilient buildings and communities that exist in harmony with nature [1]. The program revolves around six core principles in the Health and Wellbeing Framework, being:

- **Protect Health**
- **Facilitate Healthy Behaviour**
- **Prioritize Comfort**
- **Create Social Value**
- **Harmony with Nature**
- **Take Climate Action**

Principle two, Prioritize Comfort, inspired Emirates Green Building Council Health and Wellbeing Focus Day which took place on the 6th of July 2023. The focus day had panel discussions and presentations that examined five factors of comfort and their relationship to health, well-being, and productivity in Green Office Spaces. The factors were thermal comfort, Indoor Air Quality and Ventilation, Acoustics, Daylighting and Lighting, and Biophilia. The focus day ended with a panel discussion on compiling the factors and how they create a business case for health and wellbeing in interior spaces.

> ***"The factors examined were thermal comfort, Indoor Air Quality and Ventilation, Acoustics, Daylighting and Lighting, and Biophilia."***

Five Factors of Comfort

With the aim to spark a conversation among the built environment professionals in the context of the UAE, EmiratesGBC conducted a thought-sharing session to wrap up the focus day. The session was targeted at identifying the best practices to improve the 5 factors mentioned previously. The paper reflects on the outcomes of the thought-sharing session and references the different municipalities of Abu Dhabi, Dubai, Ras Al Khaimah, and Ajman building codes, and the different green building guidelines of Estidama, Sa'fat, Barjeel, and the National Green Building Code, in relation to the factors. Furthermore, local guidelines will be compared to international guidelines of ASHREA, LEED, and WELL.

The form of comparison will be through tables, to identify the extent international and national guidelines are similar or different and where international guidelines can be adapted to the region's unique needs. The mandated guidelines in the UAE have been highlighted in the different tables for the reader's reference. Following is a breakdown of each factor and its subsequent identified ways to be improved by experts and its mention in the UAE local building codes and international building codes of ASHREA, WELL, and LEED.

Thermal Comfort

"Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55)." Thermal Comfort is highly dependent on the personal perception of people, and it is a subjective analysis of a person's satisfaction with the indoor temperature. Following are key measures to address thermal comfort as outlined by the experts, mentioning possible challenges, and sharing insights on how to improve this factor specifically for the UAE.

Highlights

- Adapting a Local Temperature Range
- Integrating Smart Building System
- Optimizing Building Envelope Design

Adapting a Local Temperature Range

There is a need to find a local range of thermal comfort in the UAE. The thermal environment of the room is typically measured in three ways; by building simulation, by objective instrumental measurement, and by subjective surveys of occupants. In the evaluation process, some parametric inputs are assumed such as the outdoor climate data in the simulations, the rates of infiltration, assumptions about thermal properties of building materials, and assumptions about occupant behavior. Thus, the local condition of the building context is a key input for thermal performance measurement [3].

> ***In a study by AlNakhlah et al, that covered 1101 subjects, in 31 air-conditioned buildings, for a large-scale study of thermal comfort in the ME, in four countries, it was noted that the thermal comfort range, specified by international standards, failed to predict the thermal sensation of 94% of the occupants [4].***

The results shed light on the fact that more studies need to be done to investigate the regional and local thermal comfort range, which will impact the cooling energy demand in a region that is considered mostly hot and arid [4].

Integrating Smart Building Systems

Smart buildings system also provides an innovative solutions to improve thermal comfort as alternatives to natural ventilation in winter and artificial ventilation in the summer. Natural ventilation can help save between 13% to 40% of the building's cooling energy. In Fact, a study conducted by the United Arab Emirates University and the British University in Dubai discovered that natural ventilation in the winter month can result in saving up to 18 % of the total energy [5]. However, to achieve so, a well-designed and integrated control system needs to be implemented to ensure minimum disruption to occupant comfort [6].

> ***Between 1993 and 2020, the use of AI approaches and customized comfort models has allowed for average energy savings of 21.8 to 44% and average comfort improvements of 22.7 to 86% [7].***

The discussion on smart buildings is gaining momentum; the Ministry of Economy of the UAE shared that the growing interest in smart buildings in recent years can be attributed to the heightened awareness of the need for energy conservation [8]. Additionally, to advance smart buildings in the UAE, Dubai Municipality launched the 'Building in Dubai' platform which promotes the development of a smart, sustainable, and technologically advanced construction sector [9].

Optimizing Building Envelope Design

Lastly, in hot regions, buildings are vulnerable to extreme external factors, which increases the importance of a well-designed building envelope. Extensive studies show that adopting performance-driven designs for hot climates can result in up to a 37% reduction in annual energy consumption through effective envelope systems [10].

Elevated building envelopes' performance ensures occupant comfort by upholding stable indoor temperatures and controlling humidity levels. A passive building façade, such as a double skin façade has been shown to optimize thermal comfort and energy saving in the building [11].

> ***Thermal comfort measurements on the Predicted Mean Vote (PMV) and the Predicted Percentage of Dissatisfaction (PPD) scale have shown an improvement from 1.5. PMV of 50% PPD, for the single skin façade to 0.5 PMV with an average of 4% PPD in double skin facade offices [12] .***

Utilizing high-performing materials, like insulators in hot and arid climates in optimized building façade can result in a 30-40% reduction in overheating of the space. As per the Pearl Rating System of Abu Dhabi, in the section on Integrated Development Processes, there are specific guidelines to ensure the installation of a high-performance building envelope [13]. Moreover, the Dubai Green Building Code has dedicated Part E in its guidelines to inform on the building envelope, encompassing segments concerning facade construction, energy preservation, eco-friendly materials, and moisture management [14].

Local and International Building Guidelines and Rating Systems

Table 1 compares the indoor air condition indicators, temperature, humidity, and air speed from local and international guidelines. The guidelines state a range of values that should be achieved in a room to reach thermal comfort.

Table 1 Thermal Comfort - Local and International Building Guidelines and Rating Systems

Local Building Guidelines and Rating Systems			
Thermal Comfort			
	Temperature	**Humidity**	**Air speed**
UAE National Green Building Regulation	Dry bulb temperature: 24°C +/- 1°C	Relative humidity: 50% +/- 10%	-
Dubai Municipality building code	24°C +/- 1.5°C	50% +/- 5%.	0.2 m/s and 0.3 m/s
Sa'fat	DB: 22.5 °C - 25.5 °C	30 %-60%	0.2– 0.3m/s.
Estidama	ASHRAE 55 standard: -0.7 to +0.7 PMV with 15% PPD or -0.5 to +0.5 PMV range with 10% PPD		
Abu Dhabi Municipality building code	-	-	-
Barjeel	24°C +/- 1°C	50% +/- 10%.	
International Building Guidelines and Rating Systems			
ASHRAE 55	18°C to 27°C	40 % to 60 %	< 0.2m/sec
WELL	ASHRAE Standard 55-2013 Section 5.3, Standard Comfort Zone Compliance (see Appendix 1)		
LEED Green Building code/July 2023	ASHRAE Standard 55–2017, (see Appendix 1) and Provide individual thermal comfort controls for at least 50% of individual occupant spaces. Provide group thermal comfort controls for all shared multi-occupant spaces.		

As observed from the table, Local Regulations have kept within a close range of temperature compared to international guidelines which have relatively a larger range to achieve thermal comfort. Green Building Regulations of the Dubai Municipality specify "For all new and existing buildings, the heating, ventilation, and air conditioning (HVAC) system must be capable of providing 22.5°C to 25.5°C temperature range for ninety-five percent (95%) of the year. On the contrary as per ASHRAE, thermal comfort can be maintained from of 18°C to 27°C. As a result, a higher temperature range results in energy and cost saving as the heating and cooling system will use less energy to operate.

Indoor Air Quality

“Indoor Air Quality refers to the quality of air inside buildings as it relates to the health and comfort of the occupants. It encompasses the concentrations of various air pollutants, thermal conditions, humidity, and ventilation effectiveness." (ISO 16814:2008). In other words, indoor Air Quality (IAQ) pertains to the quality of air within and in the vicinity of buildings and structures.

Highlights

- Raising Awareness
- Incorporating Vegetation
- Installing Absorptive Material with Active Ingredients
- Installing Air Purifiers

IAQ is measured by using sensors that quantify the concentration of various indoor air contaminants, mainly Volatile Organic Compounds (VOCs), Carbon Dioxide (CO_2), and Suspended particulate Matter (PM_{10} and $PM_{2.5}$). VOCs are gases emitted from solids and liquids, and the main sources of VOCs in buildings are paints, air freshener sprays, wood finishes, carpets, and cleaning products [15]. PMs are tiny particles of dust, smoke, and liquid droplets suspended in the air. Moreover, CO_2 is the most popular IAQ indicator, CO_2 is an indicator of the rate of fresh air supply because it increases as the occupants and activities increases [15]. Generally, to measure IAQ, sensors are placed by the exhaust duct to determine the concentration of the contaminants in the air.

Raising Awareness

Lack of awareness among residents of the UAE on IAQ, is one of the constraints to improving the status of IAQ. Despite the observation of the effects of poor IAQ like stinging eyes, upper respiratory infections, sore throat, headache, and skin diseases, improvements are seldom adapted. These symptoms are recognized to be caused by Sick Building Syndrome (SBS), albeit it varies from person to person.

Research conducted in townhouses in Dubai showed that 52% of the residents expressed a lack of awareness on IAQ and the impact of poor IAQ [16].

The same research found a significant level of awareness gap amongst developers where an overwhelming percentage of developers, more than 80%, expressed a lack of knowledge on the mechanism of improving IAQ, like the eco-friendly materials, air purifiers, and ventilation mechanisms which are of great benefit. In addition, analyses on simulating symptoms in connection to Sick Building Syndrome are scarce, nonetheless, suggesting that this phenomenon has not yet received much attention from the academic community [16].

Similarly, the UAE National Air Quality Agenda outlines the absence of a clearly defined strategy and the lack of public awareness on the topic of indoor air quality [17]. To mitigate this the National Agenda proposes increasing the technical knowledge of professionals and creating frameworks outlining air quality management concepts into strategic work across disciplines such as urban planning, health, and education. Additionally, the framework outlines the need to collaborate with higher education institutes to promote scientific and academic research.

Incorporating Vegetation

Vegetation should be incorporated in both indoor and outdoor environments. In addition to improving one's home's outward appeal, plants are natural air cleaners. When there are trees outside, cleaner air will enter the indoor environment through windows and vents, improving the quality of the air within [18]. Indoor plants have shown a significant reduction in CO_2 concentration in indoor spaces.

A study conducted at a university in Ajman found that adding 15 % of the total floor area as greenery and vegetation can result in a 50% reduction in the total CO_2 concentration in the classroom, and they are perceived to be 40% fresher [19].

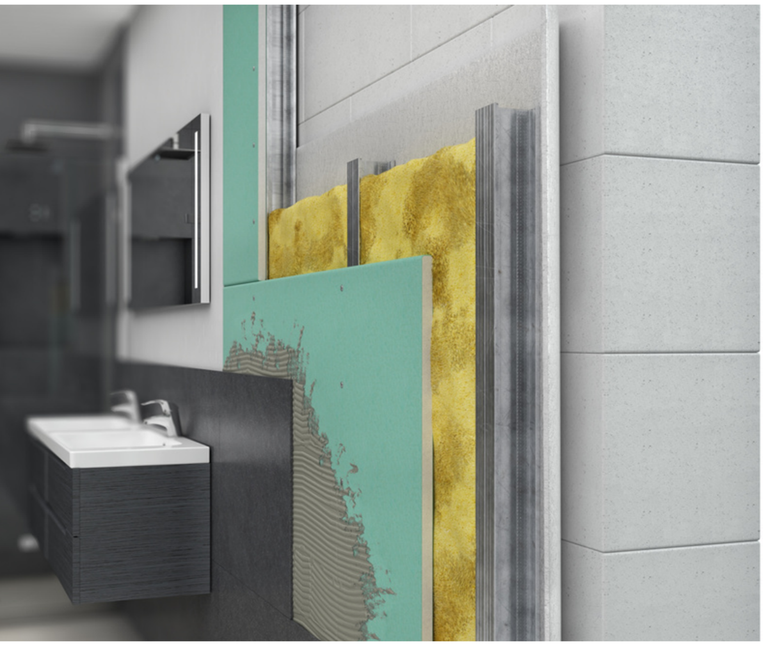
Installing Air Purifiers

Air purifiers have become an integral part of indoor design solutions to improve indoor air quality. As the IAQ is becoming more recognized among residents in the UAE, air purifiers are being highly adapted in indoor spaces. Air filtration significantly lowers the quantities of indoor pollutants.

In research conducted on air purification function technologies in indoor microenvironments, air filters are 90% effective at removing particulates [20].

Installing Absorptive Material with Active Ingredients

In addition to indoor plants, installing the right material for indoor finishing aids in improving the IAQ. Absorptive indoor finishing materials can be integrated to remove VOCs. VOCs are compounds found in the air due to the high vapor pressure and low water solubility of some materials at room temperature.



As mentioned, the common source of VOCs in rooms comes from paints, cleaning products, and interior furnishings. Furthermore, studies have found that around 10 VOCs are 2 to 5 times higher in indoor air compared to outdoor air conditions. One example of absorptive materials is gypsum board which has active ingredients that remove indoor contaminants from the space. For example, there are Gypsum Boards that have been adapted with preventative measures against sick building syndrome, by physically absorbing or reacting chemically with the air to remove harmful substances.

A study found that with optimized temperature and humidity conditions, adding absorptive materials can reduce up to 40% in formaldehyde, the most common indoor VOC [21].

Local and International Building Guidelines and Rating Systems

Table 2 compares the typical indoor air quality indicators, VOCs, CO_2, and PMs from local and international guidelines. The guidelines require an indoor air quality test to be undertaken before occupancy to determine the key indicators. The resulting values indicated in the table are the upper limit in the indoor air environment.

Table 2 Indoor Air Quality- Local and International Building Guidelines and Rating Systems

Local Building Guidelines and Rating Systems			
Indoor Air Quality			
	CO_2	**Particulate Matters**	**VOCs**
UAE National Green Building Code	ASHRAE Standard 62.1- 2013: All particulate matter filters or air cleansers shall have a Minimum Reporting Efficiency Rating (MERV) of 6.		
Dubai Municipality building code	< 800ppm	(<10 µm) <150 µg/m³	300 µ g/m3
Sa'fat	< 800ppm	(<10 µm) <150 µg/m³	300 µg/m3
Estidama	< 1000ppm	- PM 10 - 50 µg/m3 PM 2.5- 15 µg/m3 (from ASHRAE 62.1.2007)	95% of all surface areas covered by paints and coatings per Annex II, Phase II, Table A of European Directive 2004/42/CE: 2004. (see Appendix 2.1) 95% (by weight) of all adhesives and sealants must not exceed South Coast Air Quality Management District Rule 1168
Abu Dhabi Municipality building code	< 1000ppm	-	-
Barjeel	Utilize the RAK ventilation calculator to assess compliance with the ASHRAE 62,1-2013: with Air filters with a minimum Reporting Efficiency Rating (MERV) of 6. (Refer back to Barjeel Guidelines page 84)		

International Building Guidelines and Rating Systems			
ASHRAE 62-1	Table C-1 National Ambient Air Quality Standards for the Unites States (see Appendix 2.2)		
WELL	< 800 ppm	$PM_{2.5}$ less than 15 μg/m³ PM_{10} less than 50 μg/m³	Total volatile organic compound less than 500 μg /m³.
LEED Green Building Code	ASHRAE 62.1-2016	PM 2.5 12 μg/m3 PM 10: ISO 14644-1:2015, cleanroom class of 8 (3,520,000 of ≥ 0.5 micron) or 50 μg/m3 and Healthcare only: 20 μg/m3	500 ug/m3,

For indoor air quality, international guidelines have tighter regulations when it comes to the concentration of CO_2 in indoor environments. In terms of VOCs and particulate matter tests, the local guidelines adapt international standards to conduct the test and put forward the limits on ventilation. Additionally, it was noted that both the National Green Building Code and Barjeel require the use of air filters with a minimum of 6 MERV rating. The need to provide specific air filters and the significance of focusing on PMs stems from the fact that the UAE specifically, due to its nature, exhibits higher levels of PMs according to the WHO annual air quality guideline value [22]. Therefore, it is crucial to devise more local guidelines related to mitigating PMs.

Acoustic Comfort

Acoustic comfort is the perceived state of well being and satisfaction with the acoustical conditions in an environment. However, Acoustic comfort is quite subjective, and different people may interpret noise sources that have the same physical qualities differently. Thus, when measuring acoustic comfort, personal and cultural traits like sensitivity to noise and attitude towards a noise source are crucial. In the discussion with experts, it was noted that there was a lack of awareness when it comes to the acoustic comfort of occupants, as well as other points that were touched upon as mentioned below. Additionally, there are international guidelines that provide the framework for achieving an acceptable standard, for instance, the AHRI and ISO standards provide various sound and vibration standards that are available for use.

Highlights

- Raising Awareness
- Avoiding Over Design of HVAC Equipment
- Improving Reverberation Time
- Hiring Acoustic Professionals

Raising Awareness

There is a pressing need to increase awareness among built environment professionals to improve the acoustic environment in the buildings. Excessive noise in an office has been shown to increase irritation and disturb sleep in a living space. Thus, the acoustic environment is of great importance in indoor environments. Improved acoustic comfort in offices and classrooms has been shown to improve focus, communication, and productivity [23].

The Abu Dhabi Municipality has enacted a stricter restriction to ensure acceptable background noise from 8pm to 7am [24].

Similarly, the Environmental Department in Dubai Municipality has mandated all construction work and demolition noise should not exceed 55 decibels between 7am and 8pm and 45 decibels between 8pm and 7am [25]. Such requirements ensure a conscious consideration of sound pollution in indoor and outdoor spaces.

Avoiding Over Design of HVAC Equipment.

HVAC systems are the main noise source in indoor spaces. The low frequency, loud whirring, and humming increase the anxiety level of occupants. In hot climates the use of air conditioning is unavoidable. Given the increase in indoor occupancy, the dependency on HVAC systems has increased.

The Abu Dhabi government has introduced a certification of fan coil units that requires sound to be tested and reported to receive the QCC-PCS ASP064.01, Trustmark Certification of Fan Coil Units [26].

The noise from fans, duct-borne noise, and air terminals is transmitted to the space increasing the ambient noise in the building [27]. Thus, different design alterations can be adapted to mitigate the noise level in the room. However, it is often observed that most professionals over-design the HVAC equipment which leads to bigger equipment and bigger fans which in turn leads to more ambient noise. Therefore, the cooling load estimation in the design stage should be emphasized to determine the correct size of the equipment as a more viable solution should be proposed, one that does not compromise the cost and the space of the indoor space [27].

Improving Reverberation Time

The Acoustics environment in a room can be further affected by improving the reverberation time of the room by utilizing acoustic panels because different spaces have different requirements for reverberation time.

Classrooms and offices have a lower reverberation time, 0.4 - 0.6 sec, while restaurants have a slightly higher requirement of 0.7 sec-1.1 sec to keep the room livelier [28].

The use of NRC-rated material integrated into the indoor finish material in the form of wall panel furniture and carpet will improve the reverberation time. NRC stands for noise reduction coefficient, which indicates the acoustic reduction capacity of acoustic panels and other surfaces in a room [29]. The NRC is measured in 0 -1 range thus the higher the NRC range the more sound the panel absorbs reducing the reverberation time [30]. Additionally, suspended ceilings have resulted in an effective reduction of reverberation time. Improving reverberation time in classrooms and offices reduces the ambient background noise making the space calm and more comfortable [28].

Hiring Acoustic Professionals

Acoustic consultants play a critical role in project planning and development. By evaluating building techniques, and locations where noise may be an issue, acoustic professionals can assist clients in adhering to local noise regulations. They carry out tests using cutting-edge apparatus to achieve their goal. They can determine reverberation periods at locations and isolate and locate noise sources with the aid of these tests. Based on their research, they produce a report that includes their evaluation and suggestions. Finally, acoustic professionals can aid in adapting the international guidelines [31].

Local and International Building Guidelines and Rating Systems

Table 3 outlines acoustic requirements for diverse building applications, focusing primarily on sound-level specifications for schools, offices, and residential buildings. Both local and international guidelines mandate specific acoustic levels to ensure optimal comfort within enclosed spaces.

Table 3 Acoustic Comfort - Local and International Building Guidelines and Rating Systems

Local Building Guidelines and Rating Systems	
Acoustic Comfort	
	Office
UAE National Green Building Code	-
Dubai Municipality building code	BS 8233 British Council for Offices' Guide to specific**- 30 dBA- 40 dBA (see Appendix 3.1)**
Sa'fat,	BS8233:1999 "Sound insulation and noise reduction for buildings, code of practice". (UK) 30 dBA- 40 dBA (see Appendix 3.1)
Ajman Municipality building code	-
Estidama	40-50 dB (A) Leq
Abu Dhabi Municipality building code	-
Barjeel	-
International Building Guidelines and Rating Systems	
ASHRAE	N/A
WELL	30 dBA -40 dBA0
LEED Green Building Code	-For any regularly occupied space Average sound pressure level from outside noise -Open office spaces and lobbies -noise criteria (NC) of 40. -Enclosed offices: maximum noise criteria (NC) of 35. -Conference rooms and breakout rooms: maximum noise criteria (NC) of 30 (25 recommended). -Teleconference rooms: maximum noise criteria (NC) of 20. -**Reverberation time:** (see appendix 3.2). Conference rooms: 0.6 seconds.

Open workspaces: 0.5 seconds.
HVAC Background noise - as per 2015 ASHRAE Handbook-- HVAC Applications,
-Reverberation 0.8 sec- 1.2 sec (see appendix 3.3)
-Peak hour Outdoor spaces 60 dBA (peak-hour)
Mid-frequency Reverb time 0.8 sec -1.2 sec.

Local guidelines refer to international evaluation criteria, mainly the Building Bulletin 93 and British standard ISO 8233, which outlines methods of obtaining acoustics recording and evaluation. The international guidelines, on the other hand, specify ambient sound pressure level and reverberation value to be achieved in each building type, which provides a clearer framework to follow.

Natural Lighting

“Natural lighting refers to the illumination of interior spaces through the use of sunlight by utilizing windows and openings.’’. Natural lighting, also referred to as Daylight, reduces the use of artificial lighting, which saves energy and hence money. Building occupants have expressed their preference for daylit rooms in multiple studies. Additionally, exposure to enough natural light at an early age in teenagers has been shown to reduce eyesight problems like short-sightedness and Myopia Boom [32]. Different uses in a building have a different daylight factor as required by the activity. According to British Standard, BS 8206, office spaces and educational spaces have an average requirement of day factor of 2%- 5% assuming a satisfactory distribution is maintained [33]. Thus, the provision of daylight is of crucial importance to the comfort of occupants.

Highlights

- Utilizing Clerestory Windows
- Acknowledging /Accounting the Effect of Glazing and Shading on Energy Usage and HVAC Load
- Balancing Daylight Distribution
- Utilizing a High-Performance Glass Solution

Utilizing Clerestory Windows

Clerestory windows supply better daylight and maximize lighting deep into a room. The use of raised windows like clerestories results in large surface areas with natural light, creating interior environments so open and bright. Generally, high-rise windows provide distributed natural light deep into the space [34]. Therefore, the higher the height of the window head the higher the amount of natural light in the room. In addition, the raised source of light minimizes the harsh glare that enters the space with eye-level normal windows [35].

A useful illumination can penetrate to a depth of approximately 1.5 times the window head height [36].

Acknowledging /Accounting the Effect of Glazing and Shading on Energy Usage and HVAC Load.

Aside from the expected energy conservation through electricity demand by incorporating the right natural light, it is worth noting the potential heat gain that arises from glazing.

On average, about 30% of a home's heating energy is lost through windows. In cooling seasons, about 76% of sunlight that falls on standard double-pane windows enters to become heat [37].

Thus, the provision of Natural light has a big impact on interior environments and HVAC system design, this is a big concern for any construction project. By providing shade, it is feasible to keep excess solar heat out of the structure and reduce the need for expensive, energy-intensive supplementary cooling, and since solar shading has a significant impact on power demand and energy consumption, incorporating solar shading into the building façade and design should always be one of the first steps in the design of HVAC systems [38]. However, throughout the winter, the sun's free heat is much appreciated as it lowers the building's heating expenses. As a result, proper design consideration for shading elements decreases the cooling load thus increasing the efficiency of HVAC and its energy usage [37].

Balancing Daylight Distribution

The depth of the room determines the natural light distribution in the room. One of the most prominent problems in daylighting is unbalanced daylight distribution. This leads to a gloomy atmosphere at the back of the room, thus, requiring artificial light. The room should be designed in a way where natural light can penetrate deep into the room to achieve the required illuminance [35].

The Dubai Municipality guidelines mandate that the depth of the room should not be bigger than 3 times the width of the wall where the window is positioned [39].

The WBDG, Whole Building Design Guide, has indicated 60ft from south to north as viable to increase natural lighting in a building. Hence, generally, the maximum depth of the room identified by considering the window area, the width of the room, and the internal reflectance should be used as a design guide [35].

Utilizing a High-Performance Glass Solution

Smart glass system controls shading through automatic response to outdoor conditions. The system limits the solar radiation entering space and maximizes the natural light in space [40]. Additionally, high-performance glass limits the heat transfer through the glazing, thus, improving the cooling and heating load of the space. This type of glass is often designed to have low emissivity (low-E) coatings and other advanced features that help control the movement of heat. By incorporating these features, high-performance glass helps maintain a more comfortable and energy-efficient indoor environment [40].

High-performance glass adaptation aids in providing an ample amount of natural light in a space without the need to compromise the energy efficiency of the building. Thus, It can reduce the reliance on heating and cooling systems, leading to lower energy consumption and associated costs. A study by the National Renewable Energy Laboratory (NREL) found that high-performance glazing in commercial buildings offers an average payback period of 5-10 years from energy savings alone. Moreover, it provides additional non-energy benefits like increased occupant productivity and well-being, further enhancing its overall value proposition [41].

Local and International Building Guidelines and Rating Systems

Table 4 shows the local and international guidelines on natural light provisions for office space. The guidelines specify the natural light requirements in terms of the depth of the room and the illuminance level to be achieved in the working plane in the office environments.

Table 4 Natural Lighting- Local and International Building Guidelines and Rating Systems

Local Building Guidelines and Rating Systems	
Natural Lighting	
	Office Working Surface illuminance
UAE National Green Building code	-
code Dubai Municipality building code	The room depth should not exceed three times the width of the wall in which the window is located.
Sa'fat	the need to provide adequate natural light. -the presence of an openable window. - 50 % glazing between east and north western orientation
Ajman Municipality building code	-
Estidama	250 lux for 50% of the occupied area
Abu Dhabi Municipality building code	-
Barjeel	-
International Building Guidelines and Rating Systems	
ASHREA	N/A
WELL	55% of the space receives at least 300 lux for 50 % of the time. Window-wall ratio as measured on external elevations is between 20% and 60%. no more than 10% of the area can receive more than 1,000 lux
LEED Green Building Rating System	Demonstrate illuminance levels are between 300 lux and 3,000 lux at both 9 a.m. and 3 p.m. on a minimum of 55 % of the occupied space. For any regularly occupied spaces, the annual sunlight exposure ASE1000, 250 (1000 lux for 250 hrs per year) does not exceed 10% of the room.

In the table above, there is some mentioning of natural light in local guidelines. Natural light is a key design consideration in the overall lighting design scheme of indoor spaces. The international guidelines provide an illuminance level to be achieved in the indoor room for a minimum percentage of the space. Therefore, it Is recommended to expand further on local regulations related to lighting and daylighting.

Biophilia: The Harmony Between the Natural and the Built Environment.

According to WELL, Biophilia is the concept that human beings have a higher affinity to other forms of life and natural existing features in their surroundings [42]. Indoor environments are usually cold and devoid of life, creating a feeling of detachment in an environment. Thus, Biophilic design aims to increase the presence of nature in an indoor environment and increase human-nature interaction. Biophilia, as a design principle, aims to increase human interaction with nature. The design features can be incorporated into the environmental element, space layout, and natural lighting. Mentioned below are several concepts to improve Biophilia in the local UAE context.

Highlights

- Raising Awareness
- Integrating Nature and the Built Environment
- Introducing Incentives

Raising Awareness

Building the capacity of professionals and clients on the importance of Biophilia and its positive impact can allow for better incorporation of biophilia from the beginning of the design process, so it becomes an integral element of space design. A study conducted in Dubai, that included 326 participants who lived in villas, high-rise building apartments, and townhouses, revealed that residents in townhouses and villas had higher accessibility to greenery thus higher satisfaction with it, whereas residents in high-rise buildings expressed limited access to greenery, thus, less satisfaction with it [43]. The same study investigated the impact of incorporating various biophilic elements, including water, plants, sunlight, and views, on stress and anxiety, stating that there is a positive correlation between exposure to biophilic features and improvements in physiological stress indicators, contributing to enhanced anxiety relief.

In biophilic cities, resilience takes on a social dimension by enhancing the adaptability of occupants, and encouraging engagement in social activities associated with nature [43].

Additionally, Biophilic elements like trees play a crucial role in minimizing air pollution and preventing floods, while also mitigating heat through shading and evapotranspiration. Thus, this stresses the need to create a holistic biophilic design approach to all kinds of spaces [43].

Integrating Nature into the Built Environment

Nature should be integrated into the building's design instead of being a separate segment of it. Ordinarily, designers think of integrating biophilia in the final stage of the design process, which presents constraints and limitations in terms of space. However, the experts suggested an alternative to this approach where biophilia is a core part of the process. Nature can be incorporated into a building form, through materials, and building views and spaces. Incorporating biopholic design from the beginning can save money and time [43].

Keller introduced the concept of "the Restorative Environmental Design" (RED), an approach that aims to connect to nature without negative impacts on the environment, such as depleting resources, pollution, and disrupting the ecosystem [43].

Introducing Incentives

Incentives can encourage building professionals to incorporate comprehensive biophilic design in buildings. In a recent study conducted in Dubai, the interviews with different stakeholders, identified as 3 policymakers, a developer, and a biophilic design educator, showed an inclination toward incentive programs rather than obligations, making them a way forward to incorporate more indoor biophilia [43].

Local and International Building Guidelines and Rating Systems

Table 5 shows requirements by International and Local guidelines for achieving biophilia in design. The requirements have recommended a ratio of greenery integration for achieving the design criteria. The table below can be utilized together with table 5, as natural light and view is one area of Biophilic design.

Table 5 Biophilic Design Local and International Building Guidelines and Rating Systems

	Local Building Guidelines and Rating Systems
UAE National Green building code	-For a landscape area of 1,000 m2, a minimum of 30% of the total Exterior Soft Landscaping area must be plants or tree species that are native or adaptive to the climate and soil of the UAE.
Dubai Municipality building code	-
Sa'fat	-For the Platinum rating ratio 30% of the roof area should be vegetation
Ajman Municipality building code	-
Estidama	50% of the Plants in the built space are Local and drought-resistant Species.
Abu Dhabi Municipality building code	-
Barjeel	For projects with total Exterior Soft Landscape areas exceeding 1,000 m2, a minimum of thirty percent (30%) of the total Exterior Soft Landscaping area, including lawns, must be landscaped using plant or tree species that are native or adapted to the climate and soil of Ras Al Khaimah.
	International Building Guidelines and Rating Systems
ASHREA	N/A
WELL	The outdoor Biophilia in the built environment should be within atleast 25% of the project site area. a. Features either landscaped grounds or rooftop gardens accessible to building occupants. b. Consists of, at minimum, 70% plantings including tree canopies (within the 25%). Potted plants or planted beds cover at least 1% of floor area per floor. A plant wall per floor, covering a wall area equal to or greater than 2% of the floor area, or covering the largest of the available walls, whichever is greater.
LEED	-

From the table, it can be inferred that the Local guidelines in the UAE do not clearly mention the concept of Biophilia. However, there is a clear requirement to use native plant types and include different percentages of green coverage depending on the guideline investigated. Additionally, there are no consistent evaluation criteria to identify biophilic elements, thus presenting a challenge to quantify the requirements. Contrary to the local guidelines, WELL provides a more detailed guideline for incorporating greenery to indoor and outdoor environment. It is recommended that local guidelines expand further to incorporate elements of biophilic design that ensure the integration of nature into interior spaces and a seamless transition between the natural outdoor environment to the indoor environment.

Conclusion

Prioritizing comfort makes a great business case as mentioned in the last panel discussion during the focus day when experts discussed compiling the different factors and designing for work-life balance. Indoor comfort is crucial for most spaces as the workers account for 90% of the assets for most corporations. Thus, the improvement of the indoor environment is directly related to the productivity of the occupants. Thermal comfort of the occupants has shown a direct relation to the productivity of the occupants. As perceived by the people, too hot and too cold indoor temperatures have resulted in a 4-6 % reduction in productivity and a 7% decline in the health of the occupant.

Similarly, a well-ventilated space with improved indoor air quality has shown a 101% increase in the cognitive skills of workers, hence improving productivity. Also, the acoustic comfort of the workers has been identified as one of the factors that affect the indoor environment. The productivity of workers has shown a 66% decline in spaces where there were distracting noises (37). As for daylighting and biophilia, an office space in Malvern, Pennsylvania, has recorded a 150% increase in collaborative space usage due to the increase in the provision of daylight and nature views from the office space. Additionally, the provision of sunlight and natural space in an environment improves sleep and encourages physical movement which in turn improves focus and productivity.

> ***The focus group unequivocally concluded that a holistic approach, incorporating the 5 key elements, is essential for enhancing well-being in interior spaces.***

Way Forward

In conclusion, the thought-sharing session during the focus Day shed light on the critical 5 factors of well-being under the “Prioritize Comfort” element of the BPFP Framework. The exploration of thermal comfort, indoor air quality, Acoustic comfort, Natural lighting, and biophilia emphasized the importance of reevaluating international standards in the context of local needs and adapting these guidelines locally. In adapting international guidelines to local contexts, the paper underscored the need to consider regional factors such as climate, cultural preferences, and regulatory frameworks. It presented a comprehensive comparison of local building codes and international guidelines for thermal comfort, indoor air quality, acoustic comfort, natural lighting, and biophilia. Thus, advocating for a more nuanced understanding of the indoor environment range in the UAE's hot and arid climate. As the built environment continues to evolve, it is crucial to have more discussions and initiatives that will play a pivotal role in shaping a more sustainable and human-centric approach to design and construction.

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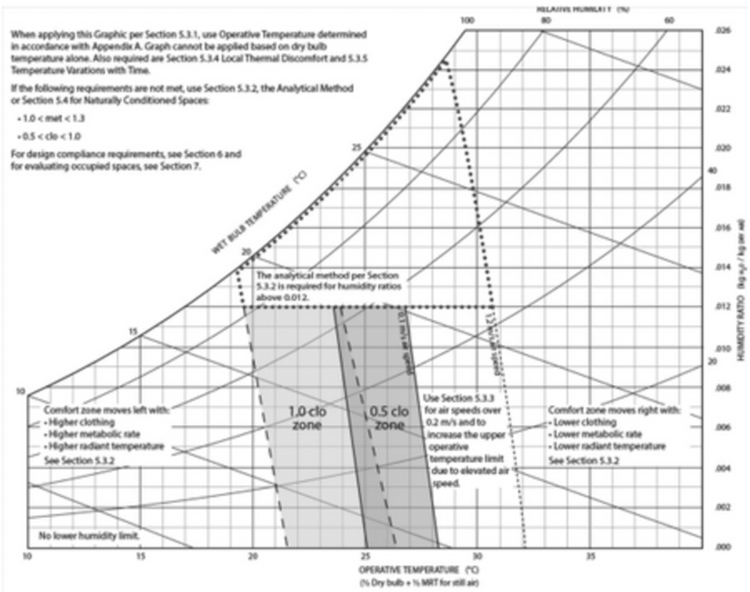
Appendix

Appendix 1 - Thermal Comfort

Appendix 1.1 - Operative temperature from ASHEREA 55 2013

(b)



Graphical illustration Adapted from ASHEREA 55 2013, by ASHEREA 2013 r, Table 5.3.1.b

Appendix 2 Indoor Air Quality

Appendix 2.1 European Directive 2004

European Directive 2004/42/CE: 2004, Annex ll, page 11

▼B

ANNEX II

A. MAXIMUM VOC CONTENT LIMIT VALUES FOR PAINTS AND VARNISHES

	Product Subcategory	Type	Phase I (g/l (*)) (from 1.1.2007)	Phase II (g/l (*)) (from 1.1.2010)
a	Interior matt walls and ceilings (Gloss < 25@60°)	WB	75	30
		SB	400	30
b	Interior glossy walls and ceilings (Gloss > 25@60°)	WB	150	100
		SB	400	100
c	Exterior walls of mineral substrate	WB	75	40
		SB	450	430
d	Interior/exterior trim and cladding paints for wood and metal	WB	150	130
		SB	400	300
e	Interior/exterior trim varnishes and woodstains, including opaque woodstains	WB	150	130
		SB	500	400
f	Interior and exterior minimal build woodstains	WB	150	130
		SB	700	700
g	Primers	WB	50	30
		SB	450	350
h	Binding primers	WB	50	30
		SB	750	750
i	One-pack performance coatings	WB	140	140
		SB	600	500
j	Two-pack reactive performance coatings for specific end use such as floors	WB	140	140
		SB	550	500
k	Multi-coloured coatings	WB	150	100
		SB	400	100
l	Decorative effect coatings	WB	300	200
		SB	500	200

(*) g/l ready to use

Appendix 2.2 ASHRAE 62-1 2016 Indoor Air Quality – Table C1

Recommended indoor air contaminant level : Adapted from American Society of Heating, Refrigerating and Air-Conditioning Engineers. (2013). ASHRAE standard 62-1-2016 : Ventilation for Acceptable Indoor Air Quality

TABLE C-1 Comparison of Regulations and Guidelines Pertinent to Indoor Environments [a]
(The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

	Enforceable and/or Regulatory Levels			Nonenforced Guidelines and Reference Levels			
	NAAQS/EPA (Ref. C-4)	OSHA (Ref. C-5)	MAK (Ref. C-2)	Canadian (Ref. C-8)	WHO/Europe (Ref. C-11)	NIOSH (Ref. C-13)	ACGIH (Ref. C-1)
Carbon dioxide		5000 ppm	5000 ppm 10,000 ppm [1 h]	3500 ppm [L]		5000 ppm 30,000 ppm [15 min]	5000 ppm 30,000 ppm [15 min]
Carbon monoxide [c]	9 ppm [g] 35 ppm [1 h] [g]	50 ppm	30 ppm 60 ppm [30 min]	11 ppm [8 h] 25 ppm [1 h]	90 ppm [15 min] 50 ppm [30 min] 25 ppm [1 h] 10 ppm [8 h]	35 ppm 200 ppm [C]	25 ppm
Formaldehyde [h]		0.75 ppm 2 ppm [15 min]	0.3 ppm 1 ppm [i]	0.1 ppm [L] 0.05 ppm [L] [b]	0.1 mg/m^3 (0.081 ppm) [30 min] [p]	0.016 ppm 0.1 ppm [15 min]	0.3 ppm [C]
Lead	1.5 μg/m^3 [3 months]	0.05 mg/m^3	0.1 mg/m^3 1 mg/m^3 [30 min]	Minimize exposure	0.5 μg/m^3 [1 yr]	0.050 mg/m^3	0.05 mg/m^3
Nitrogen dioxide	0.05 ppm [1 yr]	5 ppm [C]	5 ppm 10 ppm [5 min]	0.05 ppm 0.25 ppm [1 h]	0.1 ppm[1 h] 0.02 ppm [1 yr]	1 ppm [15 min]	3 ppm 5 ppm [15 min]
Ozone	0.12 ppm [1 h] [g] 0.08 ppm	0.1 ppm	j	0.12 ppm [1 h]	0.064 ppm (120 μg/m^3) [8 h]	0.1 ppm [C]	0.05 ppm [k] 0.08 ppm [l] 0.1 ppm [m] 0.2 ppm [n]
Particles [e] <2.5 μm MMAD [d]	15 μg/m^3[1 yr] [o] 35 μg/m^3 [24 h] [o]	5 mg/m^3	1.5 mg/m^3 for <4 μm	0.1 mg/m^3 [1 h] 0.040 mg/m^3 [L]			3 mg/m^3 [C]
Particles [e] <10 μm MMAD [d]	150 μg/m^3 [24 h] [o]		4 mg/m^3				10 mg/m^3 [C]
Radon				800 Bq/m^3 [1 yr]			
Sulfur dioxide	0.03 ppm [1 yr] 0.14 ppm [24 h] [g]	5 ppm	0.5 ppm 1 ppm [i]	0.38 ppm [5 min] 0.019 ppm	0.048 ppm [24 h] 0.012 ppm [1 yr]	2 ppm 5 ppm [15 min]	2 ppm 5 ppm [15 min]
Total particles [e]		15 mg/m^3					

Appendix 3 - Acoustics Comfort

Appendix 3.1- BS 8233- Sound level of non-domestic buildings

Typical noise level on non-domestic buildings Adapted from BS8233 Guidance on sound insulation and noise reduction for buildings.

Table 6 Typical noise levels in non-domestic buildings

Activity	Location	Design range dB $L_{Aeq, T}$
Speech or telephone communications	Department store Cafeteria, canteen, kitchen	50 – 55
	Concourse Corridor, circulation space	45 – 55
Study and work requiring concentration	Library, gallery, museum	40 – 50
	Staff/meeting room, training room	35 – 45
	Executive office	35 – 40
Listening	Place of worship, counselling, meditation, relaxation	30 – 35

Appendix 3.2 LEED Reverberation Time Requirements

LEED Reverberation time requirements - Adapted from ASHRAE (2007d), ASA (2008), ANSI (2002), and CEN (2007)

Room type	Application	T60 (sec), at 500 Hz, 1000 Hz, and 2000 Hz
Hotel/motel	Individual room or suite	< 0.6
	Meeting or banquet room	< 0.8
Office building	Executive or private office	< 0.6
	Conference room	< 0.6
	Teleconference room	< 0.6
	Open-plan office without sound masking	< 0.8
	Open-plan office with sound masking	0.8
Courtroom	Unamplified speech	< 0.7
	Amplified speech	< 1.0
Performing arts space	Drama theaters, concert and recital halls	Varies by application
Laboratories	Testing or research with minimal speech communication	< 1.0
	Extensive phone use and speech communication	< 0.6
Church, mosque, synagogue	General assembly with critical music program	Varies by application
Library		< 1.0
Indoor stadium, gymnasium	Gymnasium and natatorium	< 2.0
	Large-capacity space with speech amplification	< 1.5

Appendix 3.3, Design guide for HVAC related back ground noise, ASHEREA Handbook

Design Guidelines for HVAC-Related Background Sound in Rooms adapted from ASHRAE Handbook sound and vibration control Chapter 48

Table 1. Design Guidelines for HVAC-Related Background Sound in Rooms

Room Types		Octave Band Analysis[a] NC/RC[b]	Approximate Overall Sound Pressure Level[a] dBA[c]	dBC[c]
Rooms with Intrusion from Outdoor Noise Sources[d]	Traffic noise	N/A	45	70
	Aircraft flyovers	N/A	45	70
Residences, Apartments, Condominiums	Living areas	30	35	60
	Bathrooms, kitchens, utility rooms	35	40	60
Hotels/Motels	Individual rooms or suites	30	35	60
	Meeting/banquet rooms	30	35	60
	Corridors and lobbies	40	45	65
	Service/support areas	40	45	65
Office Buildings	Executive and private offices	30	35	60
	Conference rooms	30	35	60
	Teleconference rooms	25	30	55
	Open-plan offices	40	45	65
	Corridors and lobbies	40	45	65
Courtrooms	Unamplified speech	30	35	60
	Amplified speech	35	40	60
Performing Arts Spaces	Drama theaters, concert and	20	25	50
	Music teaching studios	25	30	55
	Music practice rooms	30	35	60
Hospitals and Clinics	Patient rooms	30	35	60
	Wards	35	40	60
	Operating and procedure rooms	35	40	60
	Corridors and lobbies	40	45	65
Laboratories	Testing/research with minimal speech communication	50	55	75
	Extensive phone use and speech communication	45	50	70
	Group teaching	35	40	60
Churches, Mosques, Synagogues	General assembly with critical music programs[e]	25	30	55
Schools[f]	Classrooms	30	35[c]	60
	Large lecture rooms with speech amplification	30	35	60
	Large lecture rooms without speech amplification	25	30	55
Libraries		30	35	60
Indoor Stadiums, Gymnasiums	Gymnasiums and natatoriums[g]	45	50	70
	Large-seating-capacity spaces with speech amplification[g]	50	55	75

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