GSAS 2019
DESIGN & BUILD
GUIDELINES MANUAL

Building Sustainably

FOR BUILDING TYPOLOGIES

Dr. Yousef Alhorr, Founding Chairman

4th Edition

المنظمـــة الخليجيـــة للبحـــث والتطويـــر
Gulf Organisation for Research & Development

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GSAS 2019 DESIGN & BUILD: GUIDELINES MANUAL FOR BUILDING TYPOLOGIES

4th Edition

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Dr. Yousef Mohammed Alhorr
Founding Chairman

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A MESSAGE FROM

Founding Chairman

The UN Urbanization Prospects Report 2014 states that 54 percent of the world's population is residing in urban areas, and by 2050, 66 percent is predicted to be urbanized. Continued population growth and urbanization are projected to add a further 2.5 billion people to the urban population of the world by 2050.

To put this urbanization issue into a GCC context, close to 90% of the population in Gulf countries will be in cities by 2050.

Cities are the hub of human life. It is critical to ensure that while we focus on the comforts of living, the cities remain sustainable, resilient and low-carbon. Sustainability is a way of life, which apart from reducing the environmental, social and economic burden, it also determines the quality of life and how human wellbeing is taken care of. As most of our time is spent in buildings and using associated infrastructure, they are the most common denominators that determine how sustainable the cities are and can be. Worldwide regional and international organizations are tirelessly working and cooperating to make cities better places to live with a special focus on the built environment.

Out of a deep concern on unsustainable urban living- especially in the Central and Western Asian continent, in 2007 GORD developed and implemented the green building and infrastructure certification system. This recognizes the pioneering efforts of the developers, contractors, practitioners and entire construction community that has assumed responsibility to care for the cause of sustainability. GORD has come a long way since stewarding the Global Sustainability Assessment System (GSAS), formerly known as (QSAS), the Middle East's first integrated and performance-based assessment system. Our mission is to encourage the development and implementation of sustainability principles and imperatives which stems from our vision on sustainable development of the region as well as globally. Over the last few years we have established a clear link of what we are doing in GSAS with the achievement on multiple Sustainable Development Goals of the United Nations. GSAS draws from top tier global sustainability systems and adds new facets and dimensions to the current practices in assessing the sustainability of the built environment. Over the years, GSAS has become one of the most comprehensive systems to date, that addresses the built environment from a macro level to a micro level targeting a wide range of building typologies and infrastructure projects.

GSAS Certifications now cover all the dimensions to assess and certify the sustainability of the built environment, be it design, construction or operation of projects. This performance based dynamic system, equipped with continually reviewed benchmarks and best practices, is a great tool in the hands of the building community to continually improve the sustainability standards of the built environment.

I would like to acknowledge the efforts and contributions from the State of Qatar, all our members, international partners and the associated consultants who helped in establishing the system and take it into new dimensions. Finally, the continuous support from Qatari Diar Real Estate Company (QD) and the Supreme Committee for Delivery and Legacy (SC) are highly appreciated, and without their support, GSAS would not be able to achieve what it has done in such a short space of time.

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PREFACE

Global Sustainability Assessment System (GSAS) is the first performance-based system in the Middle East and North Africa (MENA) region, developed for assessing and rating the buildings and infrastructures for their sustainability impacts. The primary objective of GSAS is to create a sustainable built environment that minimizes ecological impact and reduces resources consumption while addressing the local needs and environmental conditions specific to the region. GSAS adopts an integrated lifecycle approach for the assessment of the built environment including design, construction and operation phases.

The 4th Edition of GSAS launched in 2019 has capitalized on 10 years of experience and 'hands-on' implementation of GSAS, richness and capacity gained from the assessment of numerous and various building typologies totalling more than 217,000,000 square feet of built-up area and more than 1,872,000,000 square feet of district masterplanning, and multi-disciplinary research projects conducted in collaboration with renowned world-class institutes on various aspects of sustainability in the built environment.

GSAS supports the project stakeholders with manuals and tools to aid projects in the implementation of the certification processes throughout the various phases of project development from pre-design to post-occupancy.

The purpose of this manual is to provide recommendations and guidance for the effective implementation of the sustainable goals of each of the criteria identified within GSAS Design & Build Certification.

Each criterion has associated guidelines to provide designers with descriptive information for consideration to help attain the targeted level. These suggestions are in the form of recommended strategies, methods and measures. Individual developments should consider and assess the potential advantages and benefits of the recommended design guidelines in relationship to the specific goals, requirements, and conditions of the development.

The guidelines are not intended to provide specific or explicit instruction on how to design a sustainable built environment, but rather to provide guidance and recommendations on how to approach the design issues within each criterion. Furthermore, these guidelines are by no means inclusive of all possible recommendations. Thus, all developments are ultimately expected to perform the research and analysis necessary for their specific conditions and goals to meet the sustainability requirements of the design assessment system.

This manual should be read in conjunction with all other relevant GSAS manuals and publications.

CRITERIA SUMMARY

APPLICABILITY

The table below summarizes the applicability of GSAS Design & Build criteria for different building typologies:

Legend			
√	Applicable	**N/A**	Not Applicable

No	Category / Criteria	APPLICABILITY							
		Commercial	Education	Homes	Hospitality	Light Industry	Mosques	Offices	Residential
UC	**URBAN CONNECTIVITY**								
UC.1	Proximity to Infrastructure	√	√	√	√	√	√	√	√
UC.2	Proximity to Amenities	√	√	√	√	N/A	N/A	√	√
UC.3	Load on Local Traffic Conditions	√	√	N/A	√	√	√	√	√
UC.4	Public Transportation	√	√	√	√	√	√	√	√
UC.5	Green Transportation	√	√	N/A	√	√	N/A	√	√
UC.6	Neighbourhood Acoustics	√	√	√	√	√	√	√	√
S	**SITE**								
S.1	Land Preservation	√	√	N/A	√	√	√	√	√
S.2	Waterbody Preservation	√	√	N/A	√	√	√	√	√
S.3	Biodiversity Preservation	√	√	N/A	√	√	√	√	√
S.4	Vegetation	√	√	√	√	√	√	√	√
S.5	Drain & Stormwater Contamination	√	√	N/A	√	√	√	√	√
S.6	Rainwater Runoff	√	√	√	√	√	√	√	√
S.7	Heat Island Effect	√	√	√	√	√	√	√	√
S.8	Shading	√	√	N/A	√	√	√	√	√
S.9	Accessibility	√	√	N/A	√	√	√	√	√
S.10	External Lighting	√	√	N/A	√	√	√	√	√
S.11	Light Pollution	√	√	√	√	√	√	√	√
S.12	Noise Pollution	√	√	N/A	√	√	√	√	√
S.13	Eco-Parking	√	√	√	√	√	√	√	√
S.14	Mixed Use	√	N/A	N/A	√	N/A	N/A	√	√
S.15	Construction Practices	√	√	√	√	√	√	√	√

No	Category / Criteria	APPLICABILITY							
		Commercial	Education	Homes	Hospitality	Light Industry	Mosques	Offices	Residential
E	**ENERGY**								
E.1	Thermal Energy Demand Performance	√	√	√	√	√	√	√	√
E.2	Energy Use Performance	√	√	√	√	√	√	√	√
E.3	Primary Energy Performance	√	√	√	√	√	√	√	√
E.4	CO_2 Emissions	√	√	√	√	√	√	√	√
E.5	Energy Sub-Metering	√	√	√	√	√	√	√	√
E.6	Renewable Energy	√	√	√	√	√	√	√	√
W	**WATER**								
W.1	Water Demand Performance	√	√	√	√	√	√	√	√
W.2	Water Reuse Performance	√	√	√	√	√	√	√	√
W.3	Water Sub-Metering	√	√	√	√	√	√	√	√
M	**MATERIALS**								
M.1	Locally Sourced Materials	√	√	√	√	√	√	√	√
M.2	Materials Eco-Labeling	√	√	√	√	√	√	√	√
M.3	Recycled Content of Materials	√	√	√	√	√	√	√	√
M.4	Materials Reuse	√	√	N/A	√	√	√	√	√
M.5	Existing Structure Reuse	√	√	N/A	√	√	√	√	N/A
M.6	Design for Disassembly	√	√	N/A	√	√	√	√	√
M.7	Responsible Sourcing of Materials	√	√	√	√	√	√	√	√
IE	**INDOOR ENVIRONMENT**								
IE.1	Thermal Comfort	√	√	N/A	√	√	√	√	√
IE.2	Natural Ventilation	√	√	√	√	√	√	√	√
IE.3	Mechanical Ventilation	√	√	N/A	√	√	√	√	√
IE.4	Lighting	√	√	√	√	√	√	√	√
IE.5	Daylight	√	√	√	√	√	√	√	√
IE.6	Glare	√	√	N/A	√	√	√	√	N/A
IE.7	Views	√	√	√	√	√	N/A	√	√
IE.8	Acoustics	√	√	√	√	√	√	√	√
IE.9	Low-VOC Materials	√	√	√	√	√	√	√	√
IE.10	Airborne Contaminants	√	√	N/A	√	√	√	√	√

No	Category / Criteria	APPLICABILITY							
		Commercial	Education	Homes	Hospitality	Light Industry	Mosques	Offices	Residential
CE	**CULTURAL & ECONOMIC VALUE**								
CE.1	Heritage & Cultural Identity	√	√	√	√	N/A	√	√	√
CE.2	Support of National Economy	√	√	√	√	√	√	√	√
MO	**MANAGEMENT & OPERATIONS**								
MO.1	Systems Commissioning	√	√	N/A	√	√	√	√	√
MO.2	Waste Management	√	√	N/A	√	√	N/A	√	√
MO.3	Facility Management	√	√	N/A	√	√	√	√	√
MO.4	Leak Detection Systems	√	√	N/A	√	√	√	√	√
MO.5	Automated Control System	√	√	N/A	√	√	√	√	√
MO.6	Transportation Systems in Building	√	√	N/A	√	√	N/A	√	√

1.0 URBAN CONNECTIVITY

The Urban Connectivity [UC] category is concerned with the design of the proposed development having a direct impact on adjacent buildings, properties, neighborhoods, and the larger urban community.

Sustainable urban practices improve the development of neighborhoods and communities, in addition to minimizing the impacts on the surrounding environment including: climate change, fossil fuel depletion, water depletion and pollution, air pollution, land use and contamination, and human comfort and health.

CRITERIA IN THIS CATEGORY:

UC.1 Proximity to Infrastructure

UC.2 Proximity to Amenities

UC.3 Load on Local Traffic Conditions

UC.4 Public Transportation

UC.5 Green Transportation

UC.6 Neighborhood Acoustics

1.1 [UC.1] PROXIMITY TO INFRASTRUCTURE

1.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

1.1.2 PURPOSE

To minimize the amount of new infrastructure required by the development.

1.1.3 CONTEXT

An increasing percentage of the world's population is predicted to be urbanized within a few decades with an increasing number of people living in cities rather than rural areas. Cities are facing the challenges of rapid and unprecedented levels of growth requiring the delivery of adequate utilities (water, waste water, roads, transit) to people. Meeting the infrastructure requirements of a rapidly increasing population can overcome the capacity of a city to finance new infrastructure while maintaining the existing network of roads, water and wastewater facilities, schools and other public facilities and services. Therefore, it is critical to ensure that cities remain sustainable and resilient by fully utilizing the existing infrastructure and reducing the need for planning and delivery of new infrastructure.

Carefully considered and effective site selection is a crucial component of green building practice, and the proximity to infrastructure is critical for developers and building occupants as it affects the value of the development, the value of adjacent premises and the health, comfort and wellbeing of people. The presence of nearby civic facilities increases the appeal of a development and enhances the development appraisal. Development sites in previously developed areas, which are already served by effective infrastructure, reduces the need for new streets, utility lines, water supply, sewer, drainage and other infrastructure requirements. It can also inspire and lead to the reuse and renovation of existing structures. Moreover, historic buildings, vacant properties and brownfield sites can be transformed into green developments that support the local economy and strengthen the character of a community. There may be no significant additional buildings and services costs associated with new infrastructure requirements in comparison with building on previously undeveloped land.

1.1.4 GUIDELINES

- Select sites in areas where the required infrastructure is already available.
- Identify future infrastructure requirements for the selected site and undertake feasibility studies.
- Consider the proximity to existing infrastructure, including but not limited to: HV and LV electricity, gas, water, drainage, road networks, transportation networks and communication networks.
- Use existing infrastructure or eliminate the need for new infrastructure connections, to reduce the overall costs and environmental impacts associated with infrastructure construction.
- Implement efficiency improvements or measures which may eliminate the need for new infrastructure development, if the existing infrastructure is insufficient to meet the development needs.
- Consider the capacity of each of the required infrastructures.
- Consider alternative on-site infrastructure provisions to mitigate the need for new infrastructure, for example: on-site renewable energy generation, waste treatment facilities, etc.

FURTHER RESOURCES

Publications:

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1.2 [UC.2] PROXIMITY TO AMENITIES

1.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

1.2.2 PURPOSE

To select a site with surrounding amenities accessible to pedestrians and cyclists.

1.2.3 CONTEXT

The quality of life in a neighborhood is often directly connected to the richness and diversity of the amenities that contribute to the living experience in an urban environment. They are linked to the needs of daily life of people in a neighborhood. Amenities can be provided by the public sector including councils and municipalities, for example: parks, public squares, places of worship, community centers, educational facilities and recreational facilities. In addition, private sector amenities can be provided including cafés, restaurants, retail, bank, convenience stores, fitness centers, commercial offices, medical facilities, pharmacies, child care facilities and other goods or service providers. Diversity of urban amenities attracts and encourages economic activity within a city in terms of the desire for companies and people being located in places of high amenity value. The provision of amenities generates urban advantages to perpetuate the concentration of economic activity and population in and in close proximity to them. In addition, community capacity flourishes as these amenities provide opportunities for people to interact, exchange business and share common interests and concerns.

Site selection in close proximity to local amenities will reduce the need for unnecessary vehicular use and encourage an active lifestyle, creating opportunities for cycling, walking and other physical activities. Building users and occupants should be able to easily and safely access a variety of basic amenities from the proposed building and/or development.

1.2.4 GUIDELINES

- Select a site close to existing amenities to minimize vehicular transport, fossil fuel emissions and stressful traffic conditions.
- Conduct a field survey to determine the range of amenities, services, and facilities accessible from the proposed site and how they relate from a spatial perspective to the proposed development.
- Encourage highly interconnected footpath networks providing a choice of walking and cycling routes that lead to various amenities within the wider neighborhood.
- Ensure the ability to reach the greatest number of destinations within the shortest possible time while covering the shortest possible distance.
- Ensure that the proposed site plan and building layout, including the position of entrances, walkways, and roads, considers the location of existing amenities and services to ease accessibility.
- Consider, in cases where a basic range of amenities does not already exist in the nearby vicinity, providing these services within the new development to reduce the need for transportation and encourage the development and growth of the community.
- Where basic amenities do exist; consider the potential to provide complimentary amenities to increase diversity and contribute to the growth of the neighborhood.

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1.3 [UC.3] LOAD ON LOCAL TRAFFIC CONDITIONS

1.3.1 APPLICABILITY

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1.3.2 PURPOSE

To minimize the impact of the development on the local traffic conditions.

1.3.3 CONTEXT

One of the primary causes of traffic congestion is the construction of new developments without an analysis of existing traffic conditions and the implementation of adequate mitigation measures. Congestion covers several traffic aspects, such as queuing, reduced speeds and an increase in travel time, which negatively affect the economy growth and generate multiple impacts on the urban environment. Other impacts include, poor quality of life, stress, health and safety issues. Factors to be considered in traffic management include: congestion reduction, points of conflict, continuity of traffic flow, unmanageable traffic loads and road safety improvement.

New developments tend to improve traffic behavior and land-use patterns. Two types of measures can be implemented to mitigate impacts on traffic:

a) those related to land-use policies which are, in many countries, used to ensure growth control often by a form of zoning regulations, to decrease or restrict development in urbanized areas and to control the types and densities of development

b) those related to site-specific transportation measures, which include; adequate accesses, internal roads and parking areas to facilitate on-site traffic flow and avoid queues disrupting the traffic of adjacent and nearby roads, and adjacent and nearby road network capacity improvements, by modifying the geometry and/or signing.

All these mitigation measures must be based on the conclusions of a traffic impact study implemented to assess if the surrounding road network of the new development will be capable of handling the increased traffic generated while maintaining an acceptable level of service. The primary functions of the traffic impact study are: to determine the existing traffic conditions on the road network surrounding the proposed development; to estimate the additional traffic likely to be generated by the proposed development; to assess the impact of additional traffic on the existing and future road network system; and to identify roadway improvements and alterations in the site plan of the proposed development considered necessary to minimize traffic impact.

Based on the findings of the traffic impact study, transportation measures are identified and recommended to mitigate the traffic impact on the surrounding road network. Primarily, these improvements are related to the traffic flow within the site, and can include access locations, internal circulation and parking facilities. Financial measures, funding or co-funding by the developer may also be proposed and recommended as a source of funding for additional infrastructure facilities and other improvements that are required on the road network to manage the traffic generated by new development.

1.3.4 GUIDELINES

Improvements within the site

- Improve access to manage the traffic flow entering or exiting the development site. Potential improvements could include a widening of entrance and exit points or the provision of exclusive lanes for turning maneuvers. Queues should not restrict internal circulation within the development site or out-of-site movements. Entrance and exit lanes should have sufficient capacity to ensure performance and safety of operations issues are not compromised.
- Improve circulation internally to manage the traffic flow within the development site. Proper footpath markings must be made, with signage located to ensure the safety of all users. The radii of curves should be adequate to satisfy the turning requirements of larger vehicles. Bridges and other landscaping elements or features should be able to withstand the additional stress of heavy vehicles.
- Include parking facilities and loading docks for the regular loading and unloading of goods as appropriate for the specific development. Providing zones for loading and unloading for both guests and goods on the site will relieve traffic loads on the local infrastructure, minimizing the impact of congestion on the larger community.
- Ensure the design of loading/ unloading ramps is carefully considered: they should satisfy requirements, be spacious and, if possible, concealed from public view, therefore enhancing visual appearance.
- Apply, if applicable, demand management methods to reduce the number of vehicles using the road network going to the development site and using the internal road network and parking spaces. Cooperate with the relevant transit authority to reroute buses to stop at the site, and programs for matching commuters, in addition to incentives for ride sharing, for example: bonuses, free parking, special permission to park closer to the entrance, have the potential to reduce the number of vehicles on-site.
- Ensure an adequate parking arrangement to reduce points of conflict within the development site and reduce the accumulation of vehicles at access points. The provision of adequate signage is necessary to manage vehicles in the parking areas.

- Provide an appropriate amount of parking on the site and reduce parking needs by providing alternative modes of transportation.
- Ensure that parking layouts permit sufficient space for the maneuvering of heavy vehicles. Vertical clearances should be designed to satisfy the requirements for over-sized vehicles.
- Encourage bicycle transit by providing designated road space for cyclists with care given to road junctions and other zones that may cause conflicts for various vehicles.
- Enhance pedestrian travel by providing safe, well-marked sidewalks and path systems.

Improvements of road network capacity

- Coordinate, where possible, with transit authority the intersection operation by redesigning traffic signal timing and phasing, cycle length, and coordination of timings etc...
- Explore, where possible, the opportunity to improve the intersection layout and geometry by including additional lanes, widening, moving the central reservation etc. When additional lanes are not feasible, an overpass or underpass could be constructed to decrease traffic at the intersection close to the development.
- Coordinate, where possible, with the transit authority for the installation of traffic signals at intersections where signals do not currently exist to manage the increased traffic generated by the development.
- Coordinate with the transit authority for arterial road improvements which may include the provision of pedestrian crossings, making U-turns possible, provision of walkways and other facilities to supplement the improvement.
- Coordinate with the transit authority for highway interchange improvements if the site is close to a highway facility by introducing new access ramps, or improved existing ramps, together with proper traffic management in the merging and weaving areas.

EDUCATION Scheme

- Provide students with buses and encourage car-pooling to reduce the load on local traffic. Bus stops and carpool pick-up/drop-off areas should be secure and located where they are easily monitored by teachers and administrators.

MOSQUES Scheme

- Ensure that existing roads and intersections have the capacity to handle future traffic loads from the mosque, especially during peak times. Peak times include hours of prayer services, Friday midday, and evenings throughout the holy month of Ramadan.

FURTHER RESOURCES

Websites:

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1.4 [UC.4] PUBLIC TRANSPORTATION

1.4.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

1.4.2 PURPOSE

To select a site in proximity to public transportation networks.

1.4.3 CONTEXT

Public transportation can transform communities and the lives of people living in them by promoting sustainable lifestyles and stimulating economic development. Public transportation is a benefit to all sectors of society including individuals, families, communities and businesses. From a safety perspective, it is evident that traveling by public transportation is 10 times safer than traveling by car, hence by using public transportation a person can reduce the chance of being involved in an accident by more than 90% as opposed to commuting by car. In countries where people rely on public transportation as the main mode of transport, a household can make significant financial savings using public transportation. In addition, public transportation reduces fuel consumption and consequently reduces its carbon footprint. Further, public transportation enhances personal opportunities as it enables mobility and freedom to people from every walk of life and promotes a healthy lifestyle as many users will also choose to walk to the stop or station.

Social isolation and loneliness are a serious concern for those who do not have access to private transport: the disabled, poor, elderly and unemployed. It is generally recognized that public transportation is often a lifeline to maintain interactions and engagement with the wider community. A well-planned open space and public domain for walking and cycling and public transportation that works for everyone make communities vibrant, stronger and more cohesive providing many additional opportunities for social interaction than driving.

Selecting a site near existing transportation networks will encourage the use of public transportation and reduce the need for private transportation. Transit stops should be easily accessible from the development site by pedestrians and cyclists.

Transportation services accessible to the development should be assessed for adequate frequency, especially during peak hours of the day. Analysis of the projected usage patterns of future building users is necessary to ensure that the schedule and frequency of the transportation services will accommodate future needs.

1.4.4 GUIDELINES

- Consider the location of accessible entrances to the development relative to the location of transportation stops for the ease of reaching the stops for development users.
- Provide, where possible, direct paths and walkways from site entrances to nearby transit stops.
- Ensure that paths and walkways are clearly marked and shaded from direct sunlight to encourage the use of public transportation and ensure convenient access for pedestrians and cyclists.
- Plan to directly connect varying routes of travel to ensure access to transportation leaving the development site.
- Provide necessary provisions for the use of shuttle services from the development site to a nearby transport stop if a public transport stop is not located within walking distance of the building entrance.
- Consult with local planning authorities to determine alternative sustainable transport solutions for users of the development. Future transportation networks that are planned and funded by the completion of the development may also be considered for this criterion.
- Encourage roadway designers to designate sections of road for public transportation to expedite travel, promote the functionality of public transportation and encourage the use of alternative fuels.
- Consider alternate forms of transportation such as buses, street car trolleys, subways, and trains/railways, to provide efficient and expedite travel over short and longer distances.
- Locate, if possible, stations within or near the development site or major transit hubs.
- Provide, if possible, informational guides or shuttle transportation to and from the development site to the nearest transit station. Separating railway transportation either above or below roadways, through elevated or subterranean structures, can alleviate traffic congestion and expedite both private and public transit.
- Create rate programs that reduce fees depending upon the duration of the pass or the number of trips per pass.
- Consider, during the operational phase creating incentive programs to encourage the use of public transportation, for example: reduced satellite parking fees and subsidized or complimentary transit passes, for regular building employees.
- Choose a location that offers multiple transportation options and a variety of nearby destinations.

HOSPITALITY Scheme

- Ensure nearby public transportation can support the capacity of the hotel staff and guests. If possible, during the operational phase, provide shuttle transportation from the hotel to nearby transit hubs and airports.

FURTHER RESOURCES

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1.5 [UC.5] GREEN TRANSPORTATION

1.5.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

1.5.2 PURPOSE

To provide facilities supporting the use of alternative transportation modes.

1.5.3 CONTEXT

Greenhouse gas emissions in the transport sector continue to increase and are projected to increase further in the coming years. As there is no simple and immediate solution to the challenge of meeting significant CO_2 reductions in transportation, it is evident that a large range of effective and efficient CO_2 reduction measures will have to be implemented. Statistics indicate over 90% of all road transportation relies on fossil fuel.

The number of people using cars has grown over recent years. This increased use of private transportation continues to generate several environmental, social and economic concerns. The contribution to global warming and local air-pollution from the emission of toxic and harmful substances in urban areas and pollution is threatening both human health and ecosystems. The use of private cars is also threatening the quality of urban life with increasing noise levels and accidents.

Various actions can be implemented to manipulate and control the use of private cars including financial measures, legal requirements and physical changes to the built environment. Individual developments can also introduce measures to limit private car use and make it a less attractive form of transport while promoting the use of more sustainable forms of transport. Such measures include the provision and incentive for green transportation, including shuttle buses, preferred parking or car-pooling, parking fees, transport passes, bicycle racks, locker and shower facilities for cyclists and shared cycle use.

1.5.4 GUIDELINES

- Promote diversity of green transportation modes and on-site support facilities to serve alternative transport.
- Encourage the use of low- emission vehicles, including hybrid vehicles or vehicles that use electricity or compressed natural gas (CNG) by providing adequate infrastructure.
- Provide preferred parking for vehicles using alternative fuels.
- Encourage building occupants to use shuttle services where provided.
- Provide charge points on the development site to enable the use of electric vehicles.
- Encourage the use of bicycles by providing bike racks near building entrances.
- Consider providing changing rooms, shower facilities and lockers within the development to promote cycling and pedestrian activity among building occupants.
- Consider providing bicycles lockers which are weather protected, enclosed and secured.
- Provide separate, dedicated bicycle ramps into parking areas, with no obstacles like stairs or steep slopes.

FURTHER RESOURCES

Websites:

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1.6 [UC.6] NEIGHBORHOOD ACOUSTICS

1.6.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

1.6.2 PURPOSE

To minimize exposure of the development to surrounding vehicular traffic noise.

1.6.3 CONTEXT

Noise disturbance is an increasing issue in daily life resulting from industrialization and urbanization. The environmental noise which originates from transportation sources is a significant problem in large cities and sound propagation in the urban context is further reinforced by multiple reflections from building façades. In addition, neighborhood noise including noise arising from industrial processes and entertainment premises, trade and businesses, construction sites and other street noise may worsen the noise conditions.

Noise pollution potentially contributes to hearing impairment, sleep disturbance, ear pain or discomfort, and other psychological effects. Wider effects can include economic impacts including decreased productivity, lowered property values and social impacts.

The topography of the site, development massing and type of external finishes generally influence the noise propagation in the urban environment. However, careful planning and adoption of best practices can help mitigate potential noise issues. When designing buildings, the noise profile of the area should be considered including the location of buildings, their orientation, zoning and roads networks for proper measures to be developed to minimize the potential impact of noise disturbance. Reducing noise levels outside buildings would, in turn, determine lower indoor noise levels and therefore an improved environment, without necessarily requiring direct actions on the building walls.

1.6.4 GUIDELINES

- Consider providing noise barriers as noise produced by strong sound waves or vibrations can be significantly reduced by the use of such barriers.
- Consider providing trees as they are regarded as being effective in reducing noise levels within urban environments, around major highways, and along railways lines. In addition, trees can create a more visually appealing environment and improve air quality.
- Consider the implementation of on-site and off-site traffic calming measures including speed reducing measures, no-horn zone etc. if and where necessary and in coordination with local authorities, to reduce noise levels.
- Consider implementing building refurbishment measures including: acoustic plaster, sound absorbing shading devices, the increased surface absorption.
- Consider using ceiling-mounted reflectors to balconies which can reduce the adverse effects of traffic noise on the building façades when compared to an ordinary balcony.
- Consider using acoustic glass for windows and sealed frames to fight outside noise as windows are a common weak link.
- Consider soundproofing external walls to combat outside noise.
- Consider use of secondary glazing to provide reduction of environmental noise break in.
- Consider incorporating portico/s which is an effective design element that can reduce the amount of noise that enters the interior spaces.
- Design the interior layout to keep spaces with sensitive acoustic requirements away from roadways and other sources of noise pollution. Additionally, further interior acoustic treatment such as sound absorbing ceilings, walls, floors and furniture can be used to dampen unwanted noise.

EDUCATION / RESIDENTIAL Scheme

- Avoid allocating residences and educational institutions near sites with high levels of noise from equipment or activities, airport runways or heavy industrial sites, as they are especially noise-sensitive.

HOSPITALITY Scheme

- When the location of the hotel necessitates proximity to sites of strong acoustic disturbance, for example, airports or highways, consider taking additional measures to mute the noise. Airport hotels are especially prone to noise pollution and may require additional measures to ensure proper acoustic conditions. Most of the exterior noise is transmitted into guestrooms through the windows and Packaged Terminal Air Conditioner (PTAC) units.
- It is important to choose exterior windows, doors, and building assembly materials with high Sound Transmission Class (STC) values as this will reduce the amount of noise intrusion. For best results, it is crucial that building elements designed for acoustic dampening work together as the combination of acoustically-strong building materials with acoustically-weak windows or doors can compromise the overall effectiveness of the assembly.

FURTHER RESOURCES

Websites:

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2.0 SITE

The Site category is concerned with the design of the proposed development having a direct impact on both the site of the development itself as well as any adjacent sites.

Sustainable landscaping and site design practices can improve the quality of the existing site and landscape and minimize impacts on the surrounding environment including: climate change, fossil fuel depletion, water depletion and pollution, air pollution, land use and contamination, and human comfort and health.

CRITERIA IN THIS CATEGORY:

S.1 Land Preservation

S.2 Waterbody Preservation

S.3 Biodiversity Preservation

S.4 Vegetation

S.5 Drain & Stormwater Contamination

S.6 Rainwater Runoff

S.7 Heat Island Effect

S.8 Shading

S.9 Accessibility

S.10 External Lighting

S.11 Light Pollution

S.12 Noise Pollution

S.13 Eco-Parking

S.14 Mixed Use

S.15 Construction Practices

2.1 [S.1] LAND PRESERVATION

2.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.1.2 PURPOSE

To enhance the ecological value of the development site.

2.1.3 CONTEXT

Large-scale developments present an opportunity to remediate and build on land that has been contaminated through industrial waste or other human activities, in order to protect against further contamination of the surrounding region. Furthermore, it is important to maintain, restore, or improve the land to combat desertification, prevent the further decline of water quality and preserve overall ecological health. The conservation of the natural condition of the site should account for and consider the existing topography, soil, trees, plants, groundcover, water features and wildlife habitats.

Preserving, restoring, or enhancing the site soil conditions will help to ensure healthy vegetation and wildlife habitats. The site assessment should identify critical areas in the development for example: steep slopes, areas of high-water flow and vegetative or wetland buffers. Additionally, the assessment should identify the depth and quality of existing soils and determine appropriate remediation or conservation techniques. Consequently, strategies to maintain, restore or improve the land, can be developed. Strategies may include protecting zones where existing soil and vegetation will not be disturbed, identifying zones of lower quality that will be enhanced with organic material and preventing soil erosion and compaction.

Previously developed land includes buildings, roads, parking lots or land that has been graded or altered directly by human activities. All fixed structures and surfaces to be constructed within the site boundaries are considered part of the proposed development including buildings, hardscapes, parking lots, roads and pathways. Temporary structures and surfaces, including construction-related offices, storage, parking and roads can disturb sensitive land areas and, if possible, should be located on previously developed land.

Reducing unnecessary disturbance of soil is important for conserving the natural resources of the site. Healthy soils can effectively cycle nutrients, store carbon as organic matter, maximize water holding capacity and provide a healthy rooting environment and habitat to a wide range of organisms.

Excessive soil disturbance actions can include excavating for the construction of buildings, landscaping, infrastructure, man-made waterbodies, dredging for new coastline or infilling for man-made islands.

Excavation or fill required on-site will not only decrease the ecological value of the site but will also increase the need for transport and contribute to the depletion of fossil fuels. Soil disturbance may also release natural Volatile Organic Compounds (VOCs), which leads to air pollution. Additionally, the excavation of soil to create man-made waterbodies requires a significant amount of water and therefore increases the demand for sea water desalination.

In addition, preventing erosion is important on the site as it can cause degradation to the habitat of plants and animals and strip the soil of valuable nutrients. Erosion may also cause scour in bearing soils which can undermine and cause instability of both above and below grade structural features, including earthen embankments, built structures and roadways. Therefore, developments should employ erosion control practices including preserving natural vegetation where possible, directing the run-off away from exposed soils, planting temporary groundcover and permanent revegetation of areas at risk for erosion damage.

2.1.4 GUIDELINES

- Selection of a site that has been previously developed is highly encouraged. Building on a previously developed site reduces the impact on the environment and prevents more valuable, undeveloped land from being disturbed.
- Ensure, in cases where the selected site contains both developed and undeveloped land, the footprint of the proposed development occupies those areas that have been previously developed.
- Conduct an investigation, by a specialized party, of the contaminated land to test for hazardous levels of pollution on the site. The specialist will determine strategies to remediate contaminated areas to prevent further risks to the environment and to human health.
- Ensure implementation of the remediation strategies for the contaminated land before construction begins on the proposed site.
- Determine strategies based on the type and degree of contamination, natural site features, level of short- and long-term effectiveness, available funds, and time frame for completion. All remediation strategies should have minimal disruption to the site including underground features.
- Monitor continuously the land after remediation takes place to ensure that all hazardous substances have been completely cleared from the site.
- Remediate contaminated groundwater using pump-and-treat technologies, where the water is pumped to the surface and treated using physical or chemical processes.
- Use multiple techniques to remediate contaminated soils such as in situ applications, off-site disposal, the use of bioreactors and solar detoxification technologies. The implications of all remediation techniques should be considered to minimize negative environmental impacts.

- Minimize soil compaction by identifying pathways and areas during construction for heavier equipment, in order to localize affected areas.
- Minimize the length of time soil remains barren or uncovered to avoid erosion due to wind or water. Use groundcover, mulch, and/ or sand berms in landscaped areas to prevent soil movement.
- Minimize the amount of soil that is transported into or out of the site and design the development to take advantage of natural features. Limit grading on the site and plan construction machinery routes to minimize the amount of soil compaction.
- Import, when necessary, higher quality topsoil to mix with existing soil or to replace soil of lower quality.
- Avoid soil disturbance as the best method for minimizing erosion. Erosion rates are directly proportional to the type and density of groundcover on the site. Preservation of the natural vegetation is the most efficient and inexpensive form of erosion control, greatly reducing the need for revegetation. Disturbed areas require additional means of erosion prevention and sediment control, because they are more prone to erosion and invasive weed species.
- Create buffer zones and setbacks to reduce the amount of erosion and run-off from the site.
- Restrict activities in areas with erosive potential by creating undisturbed areas with natural vegetation or areas that are suitable for revegetation with native plant species. Buffer zones and setbacks may be used to protect streams and waterways, environmentally sensitive habitats, neighboring properties, structures, roadways and pathways. Buffer zones and setbacks require low-maintenance and are easy to visually inspect. Additionally, they aid the filtration of sediment and absorption of run-off and provide habitats for native flora and fauna.
- Replant non-vegetated areas which are prone to erosion with native species to prevent further damage. Revegetation will help prevent erosion by slowing down run-off drainage on hillsides and protect soil from wind erosion. The roots of plants serve to stabilize soils and revegetation enhances water infiltration in the soil, reduces runoff and traps sediment.

LIGHT INDUSTRY Scheme

- Industrial processes have the potential to impact the quality of the land over time. The use of hazardous materials, the presence of industrial equipment and the general industrial processes that take place on-site increase the likelihood that the site can become more contaminated over time. Developments should identify the potential sources of contamination and ways to remediate the hazards over the lifetime of the development. Continued maintenance of containment and treatment systems is necessary to mitigate potential negative environmental impacts that may occur. Developments should also develop plans for handling accidents and other emergency situations that can expose people and the site to environmental hazards.

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2.2 [S.2] WATERBODY PRESERVATION

2.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.2.2 PURPOSE

To minimize ecological degradation of waterbodies affected by the development.

2.2.3 CONTEXT

Waterbodies are defined as any area that holds surface or groundwater including, but not limited to, streams, rivers, lakes, estuaries, bays, gulfs, or aquifers. These waterbodies are home to a variety of flora and fauna. Coastline development not only affects the quality of nearby waterbodies, but also the overall ecological health of the habitats dependent on them. Furthermore, in a region with limited precipitation and shrinking groundwater levels, it is especially important to conserve the remaining amount of naturally available fresh water.

Developments should protect all-natural waterbodies on the site, including coastlines and groundwater, to prevent degradation to these limited resources. In addition, new developments should reduce activities that have the potential to harm the ecological diversity of waterbodies.

2.2.4 GUIDELINES

- Prepare conservation, restoration, and/or enhancement strategies and guidelines for natural waterbodies on or nearby the development site.
- Consider including a water quality report which determines the presence of metals and hydrocarbons and other contaminants in the waterbodies present.
- Restore and rehabilitate the contaminated waterbody, if existing water contamination is found on-site.
- Prepare a geotechnical investigation report to check the presence of groundwater in the site area.
- Avoid infilling, which requires dredging areas in or near bodies of water to create new land. Dredging creates excess silt and debris in existing waterbodies in addition to destroying marine life and habitats.
- Avoid dredging on the site to protect coastlines and soils in the gulf. Also, precautions should be taken to ensure that pollutants from run-off or direct dumping from construction and industrial developments do not contaminate the water supply.

- Retain natural slopes and the topography of the site and protect existing trees and significant vegetation to maintain the direction of groundwater flow if it exists on site.
- Preserve all waterbodies collecting and removing all toxic or harmful materials to prevent contaminants from reaching waterways.
- Specify surface water management measures such as permeable surfaces, filter drains, sand filters, swales, filter strips and infiltration devices for run-off drains located in areas that have a low risk of surface water pollution. These methods treat surface water using natural processes of physical filtration, sedimentation, biological degradation and absorption into materials and soils. The degree of treatment varies with each system and should be selected based on the specific needs of the development, including the amount of water available on-site for these systems.
- Avoid the use of methods of biofiltration as they are likely to require larger quantities of water to function effectively; therefore, it is recommended to use other filtration devices to decontaminate run-off.
- Collect, store, and reuse run-off where possible to conserve water on the site and reduce the burden on public treatment facilities.
- Adhere to the coastal protection regulations which mandate provision of buffer between the boundaries of a development site and the Waterbody. These regulations protect the coast from erosion and serve as a natural filter to limit the contaminants that reach the water.

HOSPITALITY Scheme

- Hotels with private beaches should ensure that these areas are not destructive to habitats and shoreline impact should be minimal. Avoid construction near the shoreline to avoid disturbing natural ecological barriers and prevent Waterbody contamination.

FURTHER RESOURCES

Websites:

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2. "Ecological Landscape Alliance." *Ecological Landscape Alliance*, https://www.ecolandscaping.org/event-ela-conference-eco-marketplace-2019/speakers/. Accessed 1 Sept. 2019.

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2.3 [S.3] BIODIVERSITY PRESERVATION

2.3.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.3.2 PURPOSE

To preserve and enhance the natural biodiversity of the site.

2.3.3 CONTEXT

The increasing rate of development is placing significant stress on the richness of our biodiversity. Lands of habitat for wildlife species are converted into residential, commercial developments, infrastructure and other uses. Alterations to the terrain can negatively impact the ecosystems and biological diversity. The fast-paced development of land destroys and fragments the habitat of a site, impacting its quantity and quality. Development eliminates and significantly changes many important habitat features, thereby altering the habitat value of the site.

Ecologically sensitive habitats are not limited to the development site and usually extend into adjacent areas and beyond. Therefore, actions taken within the development site should consider consequences that extend well past the boundaries. Furthermore, linear developments are generally responsible for fragmentation of habitats. When habitat of ecologically sensitive species is separated by distance, their movement from one area to another can become impossible; which in turn affects their health and the ability to reproduce resulting in fewer species. Examples of sites with high ecological value are, areas containing rare and endangered wildlife species; sites with a high representation of indigenous biodiversity; key biological sites such as wetlands, seagrass beds, and mangroves and areas that could be easily rehabilitated to provide a suitable habitat for wildlife.

Biodiversity conservation aims to protect and restore habitat areas for wild plants and animals. This especially applies to conservation reliant species to prevent their extinction, fragmentation or reduction in range.

Endemic species have a greater risk of extinction relative to those that are common since they only exist in one geographic region. Rare species of organisms are those that are very uncommon, scarce or infrequently encountered in their area of occupancy. They have small populations more likely to be adversely impacted by chance demographic or environmental events. Therefore, endemism and rarity are the factors that confer the greater risk of extinction and thus the rarer and more endemic the species is, the higher the preservation conservation value.

Species richness is an analysis of the number of different species of organisms present in a specific area. Diversity depends not only on richness, but also on evenness and evenness compares the similarity of the population size for each of the species present.

The number and size of ecosystems and wetlands present in an area is an indication of the complexity of the habitat. Diversity of the ecosystem reflects the extent to which regional ecosystems are "packed" within an area, such as an area with a high ecosystem diversity will have in relative terms many regional ecosystems and ecotones.

Naturalness is one of the most significant factors in nature conservation. The naturalness of the site can be defined as the degree to which an area is pristine and characterized by native species. It has no human intervention and modification. Developments should protect all-natural habitats, natural vegetation, and wildlife on the site to prevent degradation to these limited resources. In addition, areas of the site that have been identified as ecologically relevant or valuable should be preserved.

2.3.4 GUIDELINES

- Conduct a site assessment and employ construction processes and practices that protect all habitats, natural vegetation and wildlife on the site to prevent degradation of biodiversity.
- Protect from damage all the existing features of ecological value, as identified in the site assessment study.
- Designate, where applicable, an ecological zone to protect habitats from the impact of construction processes.
- Develop, in cases where habitats and vegetation are to be disturbed during construction, a plan to restore the native ecology by replanting the disturbed vegetation and reintroducing the same species and habitats after construction is complete.
- Create a habitat conservation plan to maintain and enhance habitats and ecosystems on the site. The plan should catalog all species on-site before and after construction to preserve the biodiversity and encourage the use of native plants. The plan outlines methods to maintain, enhance and protect a given habitat type required to protect species. The plan normally includes measures to minimize any impacts, makes provisions to permanently protect land, restore habitat, and relocate plants or animals to another area.
- Reduce, if possible, the development footprint by sharing facilities, access roads, walkways within clustered developments and with existing and future buildings on adjacent sites.
- Refer to [S.4] Vegetation for a more detailed explanation of appropriate vegetation and landscaping design.

FURTHER RESOURCES

Websites:

1. "Australian Research Centre for Urban Ecology (ARCUE)." *Royal Botanic Gardens Melbourne*, 2015, https://www.rbg.vic.gov.au/science/arcue.
2. "Chartered Institute of Ecology and Environmental Management." *Chartered Institute of Ecology and Environmental Management*, 2019, https://cieem.net/.

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1. *BS 5930 Code of Practice for Site Investigations*. British Standards Institution, 1999.
2. *BS ISO 10381-1 Soil Quality - Sampling - Guidance on the Design of Sampling Programmes*. British Standards Institution, 2002.
3. Coventry, S., et al. *Environmental Good Practice: Working on Site*. Construction Industry Research & Information Association (CIRIA), 1999.
4. *Guidelines for Ecological Impact Assessment in the United Kingdom*. Institute of Ecology and Environmental Management (IEEM), 2006.
5. *National Biodiversity Strategy and Action Plan*. Supreme Council for the Environment and Natural Reserves, Qatar, 2004.
6. *UNEP Ecosystem Management Programme*. United Nations Environment Programme (UNEP), 2008.

2.4 [S.4] VEGETATION

2.4.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.4.2 PURPOSE

To vegetate the site using native, low-impact or productive plant species.

2.4.3 CONTEXT

Native and adapted plants are indigenous to a specific region or have been adapted to the local climate. They have a higher chance of survival than exotic species and provide habitats for local wildlife. Furthermore, native plant species require nominal maintenance, minimal irrigation, and little to no chemical inputs such as fertilizers, pesticides, and herbicides. Local and regional governmental agencies and/or consultants should be able to provide a list of approved and recommended tree and plant species that are appropriate for the region.

Additionally, native vegetation that is non-invasive and adapted to the local climate supports biodiversity, combats desertification, and helps to reduce the carbon footprint of the development.

Landscaping plans in a hot, dry climate should strive to reduce heat, glare, and desiccation to conserve moisture, and to control temperature for human comfort and horticultural success. In such climates, it is important to design for water-efficient landscaping, to be mindful of conserving water, and to protect the environment. Refer to the plants encyclopedia, published by GORD, for a list of recommended trees, shrubs, vines, and groundcovers well-suited for hot sub-tropical climates. The included plants are by no means inclusive of all possible recommendations, and if necessary, each development should conduct their own research for additional options. Plant species listed as ‘dry condition’ and ‘minimum’ are the hardiest plants for a desert environment and require the least amount of water. Plants that are labeled as having ‘moderate’ water requirements may necessitate some irrigation, but their inclusion is meant to provide designers with a wider selection of species that are appropriate for the region.

2.4.4 GUIDELINES

- Vegetate any area of the proposed site that are not occupied by buildings and roads and provide shade to the greatest extent possible.
- Develop a landscaping plan that provides for an appropriate amount of new vegetation on the site.
- Weigh the benefits and potential drawbacks of selecting plants that may require more maintenance and irrigation to thrive in a desert environment.

- Create an efficient landscaping plan by grouping vegetation by soil, solar, and water needs.
- Select native and/or adapted trees, plants, and groundcover should be specified for the landscape plan as they may require little water, pest control, and/or fertilizers.
- Consider the amount of water the landscape design demands especially in a region where fresh water contains a large amount of embodied energy.
- Develop a landscaping strategy to minimize the amount of lawn used as vegetative cover to lower irrigation demand, instead, increase the amount of vegetation that is ecologically sensitive to an arid climate to increase the long-term viability of the landscaping.
- Specify, where turfgrasses are used, species that require less water and are adapted to the region.
- Avoid long with narrow areas of lawn as they are difficult to mow and irrigate efficiently.
- Provide landscaped areas with adequate soil depth, proper ventilation, and appropriate levels of sunlight to encourage healthy vegetation.
- Consider the soil conditions, plant groupings, microclimate, and topography when selecting the appropriate irrigation technique. Avoid using sprinkler irrigation and other above-ground systems where possible; instead consider utilizing drip irrigation systems which slowly apply water to the plant's roots and have little chance of waste.
- Avoid invasive plants, noxious weeds, and any other vegetation that could be destructive to the site.
- Use gravel, mulch, and/or stones around plants to protect the soil from solar heat gain and water loss.
- Avoid the use of inefficient irrigation techniques, as it tends to waste water through runoff and evaporation. While spray irrigation is an efficient and easy method of watering, it can be wasteful in hot climates as a considerable amount of the water will evaporate before reaching the ground.
- Consider the use of a drip irrigation system as it creates no overspray, blocked spray, or runoff and can be installed on top of the soil or below the surface to minimize water loss due to evaporation. Additionally, it is very efficient in terms of water conservation because water is introduced directly to the roots of the plant.
- Design the irrigation systems to collect and take away excess water from the plants below grade to recycle and reuse as much water as possible.

- Consider the use of vegetated roofs to enhance the site and building. Besides providing green spaces to occupants above ground level, vegetated roofs can provide habitats for wildlife and create additional shade for the development and building users. In addition, the benefits of vegetated roofs include reduced energy costs, reduced heat island effect, extended roof life, insulation, and sound absorption.
- Limit the use of harmful fertilizers, regularly remove weeds, and prune bushes and shrubs as needed.

HOSPITALITY Scheme

- Recreation areas that are heavily landscaped should take particular care in managing lawns and landscaped areas. For lawn areas, use saline tolerant grass species that require minimal water and can make use of brackish water for irrigation. Developments should try to reduce lawn areas to only target fairways, putting greens, or areas necessary for competition, and alternate grass species according to seasonal tolerance. The need for irrigation will be reduced by designing smaller areas of lawn and installing water retention systems underneath the soil.
- During the evening, fairways, putting greens, and playing fields may be covered with clear tarps to catch and redistribute condensation to further reduce irrigation needs. Driving ranges should use lawn only on tee areas or combine lawn tees with synthetic mat tees to eliminate excess lawn. Design driving range practice fields to use the existing, non-manicured desert landscape or a combination of rocks, sand, and low-maintenance native vegetation. For other areas that do not require specific playing surface conditions, use native vegetation that requires minimal maintenance and water.

RESIDENTIAL Scheme

- Encourage publicly accessible green spaces within residential developments by providing vegetated and shaded areas to promote community development and recreation. These spaces allow for outdoor activity, community interactions, and educational environments improving the health and well-being of the community. Additionally, these spaces provide ecological benefits such as reduced heat island effects, greater storm water control, and wildlife habitats. Locate residential developments in close proximity to existing publicly accessible spaces to reduce the need to travel for outdoor recreation.

FURTHER RESOURCES

Websites:

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3. Love, Bill. *An Environmental Approach to Golf Course Development*. American Society of Golf Course Architects, 2008.
4. *National Biodiversity Strategy and Action Plan*. Supreme Council for the Environment and Natural Reserves, Qatar, 2004.
5. *Water-Efficient Landscaping: Preventing Pollution & Using Resources Wisely*. US Environmental Protection Agency, 2002.

2.5 [S.5] DRAIN & STORMWATER CONTAMINATION

2.5.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.5.2 PURPOSE

To prevent the contamination of drain and stormwater discharged from the site.

2.5.3 CONTEXT

Buildings generate different types of contaminants including solids, sludge, sediment, floating debris, oil, detergents, pool and spa chemicals, pesticides, herbicides, and scum. These contaminants should be collected and removed to prevent them from reaching public utilities. In many communities, there are two separate and independent drainage systems; one for wastewater collection – a sewer system that carries sewage from buildings and a second independent system for rainwater, or storm water. The storm water is often sent directly to the sea, lakes, artificial lagoons or rivers, if they exist, while domestic sewage is transported to wastewater treatment plants, for treatment to remove pathogens and other contaminants.

During periods of heavy rainfall, the overall volume of wastewater traveling through the collection network can greatly exceed the capacity of the sewer system or treatment plant. These overflows can contain not only storm water but also pollutants. These pathogens pose a serious risk to human health, threaten aquatic habitats and life, and can impact the use and enjoyment of waterways.

Practices to prevent contamination should include pollution prevention in addition to treatment devices and methods at source; i.e. at a development level to reduce the adverse environmental and health impacts. The degree and type of treatment may vary dependent on the specific contaminant conditions, the building use, and the public infrastructure available to the site.

2.5.4 GUIDELINES

- Consider utilizing source control systems and oil separators where necessary to prevent sewer and waterway contamination.
- Specify for runoff drains located in areas that have a low risk of surface water pollution, surface water management measures, such as permeable surfaces, filter drains, sand filters, swales, filter strips, and infiltration devices, to prevent contamination of waterways. These methods treat surface water using natural processes of physical filtration, sedimentation, adsorption into materials and soils, and biological degradation.

- Select the degree of treatment according to the specific needs of the development, including the amount of water available on the site for such systems.
- Assess the adequacy of using the various forms of biofiltration as they are likely to require larger quantities of water to function effectively, and hence other forms of filtration devices can be selected to decontaminate runoff.
- Collect, store, and reuse runoff where possible to conserve water on the site and reduce the burden on public treatment facilities.
- Specify oil/petrol separators or their equivalent to minimize the risk of further contamination for runoff drains located in areas that have a high risk of surface water pollution from substances, such as oil and petrol.
- Provide bunding or other spill prevention barriers around exterior areas in the development that contain liquid materials potentially hazardous to health.
- Clean paved areas regularly to reduce pollution from oil, gasoline, and other automotive fluids.
- Maintain and clean exterior areas in the development that contain waste or recycling facilities properly to avoid contaminating waterways with harmful substances.

HOSPITALITY Scheme

- Hotels built on the shoreline or those that have private beaches should ensure that waterbodies near the hotel are not contaminated from the large amount of sewage generated by the hotel. Avoid construction directly on the beach to avoid disruption of the marine ecosystem and topography.

LIGHT INDUSTRY Scheme

- The industrial process has the potential to generate toxic or harmful materials that must be isolated and treated. When a facility handles or generates harmful materials, proper filters and other point- source controls should be utilized as close to the source of pollution as possible. Once these materials are isolated, developments should also have the capabilities to store the materials until they can be properly disposed.

FURTHER RESOURCES

Websites:

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Publications:

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7. *Source Water Protection Practices Bulletin: Managing Stormwater Runoff to Prevent Contamination of Drinking Water*. Office of Water, U.S. Environmental Protection Agency, 2001.
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2.6 [S.6] RAINWATER RUNOFF

2.6.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.6.2 PURPOSE

To maximize the potential for harvesting and reusing rainwater falling on the development.

2.6.3 CONTEXT

In recent years the practice of rainwater harvesting has emerged as a water conservation method promoting an alternative water supply source. Additionally, excessive quantities of rainwater may damage buildings, hardscapes and vegetation on the proposed site and adjacent properties. Rainwater can be captured in diverse ways, from small-scale rainwater harvesting techniques, where water is possibly collected from rooftops, to large-scale diversion of stormwater from streams and reservoirs. Utilizing captured rainwater offers the potential for an alternative water supply for non-drinking purposes and can reduce pollution in waterways. Rainwater once harvested and treated can be used for many purposes including: irrigation, aquifer recharge, toilet flushing and janitorial uses.

Adequate rainwater management practices should be followed for low risk purposes, for example, landscape irrigation. For high-risk uses, where it is likely people will be in close contact with the harvested water, more complex management techniques and controls are necessary.

Rainwater that falls on areas of the site that are impervious or semi-pervious can be collected, stored, and treated for reuse. Such surfaces may include roofs, roads, walkways, parking and other paved areas.

Rainwater harvesting, including the collection, storage, treatment and reuse of rainwater, can be accomplished using a variety of methods and techniques. Techniques for collection and storage range from using small rain barrels to underground cisterns and tanks depending on the specific conditions of the development and site.

A rainwater harvesting and treatment system can consist of: a catchment surface, a system to channel the water, a purification system, disinfection equipment, storage tanks and a delivery/ distribution system.

2.6.4 GUIDELINES

- Minimize the volume of rainwater runoff exiting the site by promoting infiltration and reduce the amount of impervious surface area on the site where negative impacts are not foreseen.
- Facilitate the absorption of rainwater that falls directly onto landscaping, including lawn areas and planting beds. Excess water from rain and irrigation should be captured using retention basins or allowed to absorb and replenish groundwater resources where negative impacts are not foreseen.
- Provide means for capturing, collecting, storing, and reusing the rainwater that falls on the roof of the building or any other above-ground catchment surfaces.
- Implement an on-site treatment solution for the water collected from various harvesting methods. Pre-treatment often involves the use of screens, filtration devices, for example, slow sand filters, first-flush diverters, or roof washers to remove sediment and debris from the water before storage.
- Ensure the rainwater collected from roads and walkways is suitably treated as it may necessitate more stringent treatment processes to remove oils, fuels, and other harmful materials.
- Consider implementing the microbiological treatments and disinfection processes to remove deleterious substances that may include the use of cartridge filters, ultraviolet light, or membrane filtration.
- Consider the site, climatic conditions, and all the potential environmental impacts when selecting a rainwater harvesting system and the appropriate filtration and disinfection processes.

FURTHER RESOURCES

Websites:

1. "American Rainwater Catchment Systems Association." *ARCSA.Org*, https://www.arcsa.org/. Accessed 1 Sept. 2019.

Publications:

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2.7 [S.7] HEAT ISLAND EFFECT

2.7.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.7.2 PURPOSE

To reduce heat island effect of the development on the surrounding environment.

2.7.3 CONTEXT

The Urban Heat Island (UHI) effect is the expression associated with localized increased temperatures experienced in urban environments when compared with the temperatures of the surrounding space. This effect occurs when natural surfaces are replaced with hard, dark colored solid surfaces that absorb large amounts of solar radiation. In general, building facades, roads, paved areas and roofs are the most common forms of hard urban surfaces which are generally significant in area in the urban environment.

Hard, dark colored surfaces have relatively low Albedo values, the fraction of incoming radiation reflected by a body and high thermal conductivities. They typically absorb and re-radiate approximately 90% of the total incident solar radiation. This can result in an increase in summer temperatures of between 4-7°C when compared with adjacent vegetated areas.

The heat island effect has an adverse impact on energy consumption due to an increased demand on air conditioning which impact peak electricity demand and energy costs. Typically, electricity use in cities increases between 2-4% for every increase of one degree Celsius. It is anticipated these costs will increase further if global temperatures continue to rise and an increasing urbanization contributes to the Urban Heat Island effect even more significantly.

Cool surfaces reflect sunlight and emit heat more efficiently and are considered as a potential strategy to reduce the heat island effect. Therefore, materials with high solar reflectance (albedo) help reduce indirect solar gain in buildings and positively reduce the urban heat island effect. For example, roofs finished with a light-colored coating will have a lower temperature under sunny conditions when compared to a similar dark colored roof.

2.7.4 GUIDELINES

- Mitigate the impact of heat islands on the environment in the design and planning of the development.
- Consider materials with high solar reflectance (SR) values to reduce the amount of heat absorbed.

- Select light-colored paving surfaces or use paving materials of low heat capacity to minimize the amount of heat absorption from the sun.
- Provide shading with vegetation, trees, and architectural features and devices in areas with hard, impervious materials.
- Limit the area of hard surfaces that may absorb heat from the sun.
- Ensure the development layout utilizes the site in an efficient manner by stacking levels of the building, minimizing parking surfaces and sharing roads and facilities with neighboring properties when possible.
- Limit the amount of exposed parking pavement on the site by providing well-ventilated underground parking or covering parking with high-reflectance materials or vegetation.
- Install roofs with high-albedo values or are vegetated to reduce heat absorption.
- Use building materials that are light in color to reflect the heat of the sun rather than absorb it. Materials that are of high-reflectance or have low solar absorption rates will help to alleviate the thermal environment.
- Maximize green space and provide an appropriate amount of vegetation and groundcover to help mitigate the effects of heat islands by cooling the air through evapotranspiration and shading the building and pavement on the site.
- Ensure that a trade-off exists between the benefit of having abundant vegetation on a site and the amount of water it takes to sustain the vegetation—specify an appropriate level of vegetation to minimize the demand on the limited water resources of the region.
- Encourage air movement on the site through the design of the development.
- Consider the direction of prevailing winds when planning the proposed building placement, orientation, forms, and heights.
- Ensure continuity between open spaces on the site and provide gaps between buildings in the case of clustered developments to encourage airflow.

HOSPITALITY Scheme

- The use of fountains and reflecting pools is common in the design of a hotel. These features can reduce the heat island effect of the site. Water features absorb solar radiation more effectively than many solid building materials and can have a strong impact on passively cooling a space. However, exterior water features should be used sparingly or designed for use with recycled water, to reduce the load on fresh water demand due to the high evaporation rate prevalent in the region.

FURTHER RESOURCES

Websites:

1. "Heat Island Effect." *US EPA*, 28 Feb. 2014, https://www.epa.gov/heat-islands.

Publications:

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2.8 [S.8] SHADING

2.8.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.8.2 PURPOSE

To provide shading for commonly used outdoor areas.

2.8.3 CONTEXT

The sun is a source of life. The sun's rays provide our bodies with vitamin D. However, excessive heat and/or sun exposure may result in sunburn, skin cancer, heat illnesses and irritability. Therefore, avoiding direct sunlight and restricting sun exposure can mitigate the adverse impacts of over exposure through the use of properly designed shading devices.

Shade is a significant factor in the design of pedestrian-friendly outdoor spaces in hot regions. Well-designed solar control and shading devices, either artificial or natural, are a very effective means for climatizing commonly used outdoor areas. They reduce the temperature of the shaded area and provide protection from the effects of ultraviolet radiation. Outdoor shading can also block the harmful effects of glare and dust and provide privacy while enhancing the effects of cooling breezes.

Shade from objects will vary based on the time of day, i.e. morning versus afternoon times and seasonal variations. The degree of protection also varies with the angle of the sun in relation to the object. As such, the shade structure may have shade cast that is not always directly beneath the structure and in such instances no protection is provided to the object under consideration. Analysis and identification of where and when shade is needed in advance is crucial for ensuring that appropriate locations and forms of outdoor shade structure are addressed.

Hence, due to the hot temperatures and intense solar radiation in hot climates, any commonly used areas of the proposed site that are not occupied by buildings and roads should be vegetated and shaded to the greatest extent possible.

2.8.4 GUIDELINES

- Utilize shading devices and/or trees over sidewalks, walkways and bicycle paths to protect pedestrians and cyclists from the sun.
- Provide shaded paths and walkways between adjacent buildings, parking zones, green spaces and other shared facilities.
- Protect open spaces from direct sunlight using various architectural and landscaping methods. For example, shading devices, such as trellises, pergolas, awnings, canopies, or built structures, can be used to create shade. Trees, shrubs, and other forms of vegetation can also provide shade to the site.
- Ensure that picnic and seating areas can benefit from permanent shading structures, such as pavilions or fabric canopies that provide full-time coverage.
- Consider, when designing outdoor shelters and shaded areas, the time of day when the spaces are used to determine appropriate shading coverage.
- Consider the durability of materials used for architectural shading devices and all related operational, maintenance and safety issues.
- Conduct technical assessments related to sun angles on the site and utilize sun path diagrams and computer simulations to determine appropriate shading strategies for the site.
- Use computer simulations when designing a sheltered area to determine the influence of the time of day, location and orientation affecting thermal comfort.
- Ensure the provision of appropriate shading devices for entrances, parking lots, pedestrian pathways, picnic areas and other common areas to reduce heat gain, mitigate heat island effect, and encourage pedestrian activity on the site.
- Ensure that shade from tree canopies does not block the view of drivers or pedestrians.
- Use for shading native vegetation which contributes to the local ecological system. Native vegetation generally requires little maintenance once established.

RESIDENTIAL Scheme

- Encourage publicly accessible green spaces within residential developments by providing vegetated and shaded areas to promote community development and recreation. These spaces allow for outdoor activity, community interactions and educational spaces improving the health and well-being of the occupants of the development and/or district. These spaces provide ecological benefits including reduced heat island effect, greater stormwater control and wildlife habitats.

FURTHER RESOURCES

Publications:

1. Association, American Forestry. *Shading Our Cities: A Resource Guide For Urban And Community Forests*. Edited by Gary Moll and Sara Ebenreck, 1st ed., Island Press, 1989.
2. Carmona, Matthew, et al. *Public Places Urban Spaces, Second Edition: The Dimensions of Urban Design*. 2nd ed., Architectural Press, 2010.
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2.9 [S.9] ACCESSIBILITY

2.9.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.9.2 PURPOSE

To maximize accessibility to and within the site for all users, in particular those with special needs.

2.9.3 CONTEXT

People are diverse and variable in their functional capacities, size and age. Moreover, disability and illness, whether temporary or permanent, can also affect human capabilities including: mobility, reach, balance, strength, sight, knowledge or sense of direction.

Accessibility can be considered as the "ability to access" and to benefit from systems or provisions to enable access. The intent is focused on enabling access for people especially those with disabilities, or special needs, or to enable access by providing assistive technology where necessary.

Development sites that are well-connected to residences, offices, and amenities promote accessibility and convenience to users. Additionally, increasing pedestrian and bicycle access reduces the demand for vehicular transportation, thereby reducing the harmful emissions that adversely affect human health and contribute to global climate change.

Sustainable sites create an environment that makes it easy and intuitive for all users, including those with disabilities, to orient themselves and navigate from place to place. Sites that are easy to navigate enhance the users' sense of safety, minimize anxiety and improve environmental awareness.

Developers, building owners, designers and consultants have a responsibility to ensure that the built environment is accessible to all wherever it is practical to do so including, but not limited to, wheelchair users, their carers, people with walking difficulties, the visually impaired and the elderly. Design of pathways in the development should allow people of varying abilities to use open space, buildings and places in comfort and safety, as far as possible independently without the need for special assistance. The design strategy should also allow people to be able to find their way easily, provide information to identify and use the development facilities and where they may encounter traffic.

2.9.4 GUIDELINES

- Design pathways to provide direct and safe connections for pedestrians and cyclists to maximize convenience for occupants and other users of the site.
- Design pathways, if possible, to be visible from other areas on the site to foster a sense of security and promote a safer environment for pedestrians.
- Plan pathways to avoid loading zones, mechanical equipment, and other unpleasant spaces for pedestrians.
- Create a network of pathways, including pedestrian trails, bicycle paths and accessible paved pathways, on the development site.
- Consider existing pathways on adjacent sites when designing the layout of the proposed development to ensure appropriate and efficient connectivity for pedestrians, cyclists and users with disabilities.
- Ensure that pathways are designed to provide direct and safe connections. Building frontages and entrances should face the street to promote active pathways and streetscapes.
- Ensure that all pathway surfaces are of solid firm construction, free of trip hazards or obstructions and have an appropriate slip resistance, able to withstand inclement weather regardless of the specific material used.
- Provide sufficient space for the anticipated foot traffic considering the presence of other features on the pathways, for example, signage.
- Separate pathways from roadways with the use of raised sidewalks, curbs, or bollards to clearly identify the paths.
- Provide accessible pathways, including sidewalks alongside roadways and accessible paved pathways between all building entrances, throughout the development site.
- Ensure that paved pathways meant for users with disabilities meet the requirements and standards of the Architectural and Transportation Barriers Compliance Board; Architectural Barriers Act (ABA) Accessibility Guidelines for Outdoor Developed Areas, or equivalent.
- Provide accessible pathways with appropriate surface materials including tactile surfaces where recommended, proper width and slope with an appropriate lighting scheme to ensure user comfort and safety. At instances where the path is not wide enough, provide passing spaces, as recommended by the accessibility guidelines, to accommodate users with disabilities.
- Consider the use of benches and other programmed elements, including shaded accessible rest areas, where necessary.

- Use design features, including signage, awnings and identifiable entrance areas, to assist with wayfinding and walkability.
- Label pathways and building entrances clearly to allow for convenient wayfinding between facilities within the site and to adjacent properties or public transportation nodes.
- Ensure that, when vehicular traffic is anticipated to cross pathways, additional street markings and signage are used to clearly mark traffic patterns.
- Place signage at regular intervals along pathways in a position where it is visible to all the intended users without impacting the required width of pathway.
- Provide vehicular directional signage, pedestrian directional signage, labels for pathways, safety and advisory warnings and accessible signage for pathways intended for use by users with disabilities.
- Incorporate sidewalks and bicycle lanes into the design of buildings to ensure sufficient pedestrian and bicycle access along circulation routes and from roads around the perimeter of the site.
- Design the site to include additional pedestrian and bicycle pathways, separate from roadways, to provide direct access for pedestrians and cyclists between sites of interest.
- Create user-friendly open spaces that become points of interest in themselves by separating the dedicated pedestrian pathways from roadways.
- Use pedestrian pathways in conjunction with the design and layout of plazas, picnic areas, monuments, and other site features.
- Ensure pathways provide direct and safe connections for pedestrians and bicyclists to maximize convenience to building occupants and other users of the site.
- Ensure that pathways adhere to universal design standards for handicap accessibility such as providing a minimal slope and easily accessible ramps.
- Support the bicycle network by providing the proper infrastructure including bicycle parking facilities, showers, and changing spaces.
- Design a bicycle pathway network that includes different types of bicycle pathways for different road conditions and user demand and allows for maximum access to the site from the surrounding community.
- Provide bicycle pathways with the appropriate surfacing to ensure that the pathways are smooth and free of obstacles such as sewer drains, potholes, or other obstructions.
- Ensure that the traffic paint is of a bright color and contains reflective pigments to make it more visible at night.

- Place signage at regular intervals along bicycle pathways in a position where it is visible to both vehicular and bicycle traffic.
- Ensure that the design of pathways is accommodating bicycles at intersections and providing dedicated spaces for bicyclists to wait at traffic lights or well-marked turning lanes. When vehicular traffic has the potential to cross bicycle paths, additional street markings and signage should be used to clearly mark traffic patterns.
- Ensure that when bicycle pathways are not physically separated from vehicular traffic, proper signage and lane markings to alert drivers to the presence of bicycles are in place.
- Ensure that traffic paint clearly marks the bicycle path with wide paint stripes or a painted buffer between vehicular and bicycle traffic provides a better visible separation.

FURTHER RESOURCES

Websites:

1. "National Center on Accessibility: Indiana University Bloomington." *National Center on Accessibility*, http://www.ncaonline.org/. Accessed 2 Sept. 2019.

Websites:

1. Kirschbaum, Julie B., et al. *Designing Sidewalks and Trails for Access: Part I of II: Review of Existing Guidelines and Practices*. Federal Highway Administration (FHWA), U.S. Department of Transportation, 2001.
2. *Outdoor Developed Areas*. U.S. Access Board, 2014.

2.10 [S.10] EXTERNAL LIGHTING

2.10.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.10.2 PURPOSE

To meet minimum compliance requirements for external lighting and avoid over-lighting of commonly used outdoor areas.

2.10.3 CONTEXT

In external lighting the illumination quality is normally determined by the ability to perform a visual task and general visual comfort. The degree of illumination and the reflection properties of an illuminated surface influence the visual performance. In general, surfaces with light colors, for example white, have a reflection degree of up to 85%, while darker colors, a red facing brick facade has only up to 25%. Therefore, to compensate for potentially low visual performance in the case of the dark surfaces, the degree of illumination must be adjusted to ensure an optimal level of visual performance and comfort. Areas which are adequately lit will help maintain visual comfort and deter crime and vandalism.

2.10.4 GUIDELINES

- Provide light levels in accordance with those recommended in the IESNA Lighting Handbook, or other applicable standards related to a specific environment or task.
- Ensure that light levels do not significantly exceed the recommended minimum illumination levels.
- Identify where and when lighting is needed and choose the most efficient light sources that meet the visual task requirement.
- Optimize illumination intensity and energy use by selecting energy efficient lamps and fixtures
- Use shielded and full cut-off fixtures, with efficient lamps, which prove to be more cost-effective due to the reduced energy use and optimized geometry which helps to focus the light directly towards the ground. These types of fixtures also reduce light trespass and glare.
- Contain light within the site by carefully selecting, locating, mounting, and aiming the luminaires to reduce light pollution and make the system more efficient.
- Coordinate the light fixture layout with outdoor street furniture and dedicated picnic areas to maximize lighting efficacy.

- Consider the location of trees and shrub growth when locating lighting fixtures, as these may obstruct the intended light distribution.
- Consider paving material properties and reflectivity when calculating light levels.
- Ensure the lighting system meets security and safety requirements in a public setting, where facial identification may be required. The following factors should be considered when specifying fixtures to improve light quality and reduce shadows: luminance ratio limits, veiling reflections, reflected glare, shadows, color, and intensity.
- Consider accessibility for maintenance when design the lighting system.

FURTHER RESOURCES

Websites:

1. "Illuminating Engineering Society." *Illuminating Engineering Society*, 2019, http://www.ies.org/.
2. "International Dark-Sky Association (IDA)." *International Dark-Sky Association (IDA)*, https://www.darksky.org/.

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1. Boed, Viktor. *Controls and Automation for Facilities Managers: Applications Engineering*. CRC Press, 1998.
2. *Code for Lighting. Part 2 - Recommendations*. Chartered Institution of Building Services Engineers (CIBSE), 2002.
3. Rea, Mark S. *The IESNA Lighting Handbook*. Illuminating Engineering Society of North America (IESNA), 2000.
4. *Recommended Practice of Daylighting (RP-5-99)*. Illuminating Engineering Society of North America (IESNA), 1999.

2.11 [S.11] LIGHT POLLUTION

2.11.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.11.2 PURPOSE

To minimize the amount of light emitted from the development.

2.11.3 CONTEXT

Light pollution can impact the environment through effects including light trespass, glare and sky glow, which should be minimized through the design of an efficient and sustainable lighting scheme. Lighting design of a building should be based on the specific development needs, functions and site conditions, with the intention of reducing the effects of light pollution. Computer modeling and simulations can be used during the design stage to analyze lighting conditions and thereby improve the lighting design to reduce the effects of light pollution resulting from external lighting and light trespass from within the development.

IESNA-RP 33 standards, for example, can be used to determine which zone (Zone E1 – Zone E4) the proposed development is classified and the requirements and standards for that specific zone should be complied with. In addition, local regulations such as lighting ordinances or bylaws relevant to the site should be reviewed and considered before designing the lighting scheme.

2.11.4 GUIDELINES

- Minimize, where possible, the amount of light used on the development site including lighting used for architectural and landscape features such as plazas, courtyards, walkways, buildings, trees, and planting beds.
- Cluster the fixtures where necessary to highlight specific features, consider light beam directions to reduce light dispersion and disturbance to the environment.
- Avoid upward lighting schemes, if external lighting is needed for safety and security purposes, consider the use of low-intensity, highly focused lamps; shielded and full cutoff luminaires; low-reflectance external finishes to minimize light pollution.
- Ensure that all non-essential external lighting is automatically dimmed to lower illumination levels or switched off after normal operating hours to minimize energy consumption and environmental disturbance.
- Ensure that the lighting in parking lots is zoned so that the area closest to the building can be activated without illuminating the entire lot.

- Ensure that all selected lighting fixtures and lighting controls equipment meet high performance and quality standards, to maximize visual quality, system efficiency, and reduce the need for frequent maintenance.
- Use energy efficient lamps and fixtures to reduce power consumption and optimize illumination intensity.
- Avoid light trespass which occurs when direct beams from interior light fixtures permeate transparent and translucent surfaces of the building envelope.
- Determine the direction and intensity of each fixture type and locate interior lighting fixtures such that the direct beam illumination intersects opaque building surfaces or dissipates before reaching the exterior. The direction of maximum luminous intensity can be found using manufacturers' candela plots or photometric data.
- Install lighting system controls that allow for the automatic dimming or switch-off of all non-emergency interior and exterior lighting fixtures after normal operating hours.
- Consider using automatic sweep timers, occupancy sensors, motion detectors, or programmable lighting control panels.
- Ensure that the lighting system design includes the capability for manual override for use after normal occupancy hours.

EDUCATION Scheme

- Nighttime, outdoor events require intense illumination. Use shielded luminaires at outdoor facilities to significantly reduce light trespass to adjacent sites. Luminaires for outdoor facilities adjacent to roadways should not create any glare issues on the local road network.
- Since a variety of user groups visit educational facilities, including full-time occupants including employees and students and part-time occupants who only attend events, all external and internal lighting should be zoned to meet the demands of these user groups and optimize efficiency based on the occupancy levels and usage patterns. On occasions when a smaller number of occupants use the facility, fewer lights may be kept on, whereas certain peak event times may require maximum lighting use.

FURTHER RESOURCES

Websites:

1. "Illuminating Engineering Society." *Illuminating Engineering Society*, 2019, http://www.ies.org/.
2. *Institution of Lighting Professionals*. https://www.theilp.org.uk. Accessed 28 Aug. 2019.
3. "International Dark-Sky Association (IDA)." *International Dark-Sky Association (IDA)*, https://www.darksky.org/.

Publications:

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2. *Guidance Notes for the Reduction of Light Pollution*. The Institution of Lighting Engineers, 1992.
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6. *PLG 5 Brightness of Illuminated Advertisements*. Institution of Lighting Professionals, 2015.
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2.12 [S.12] NOISE POLLUTION

2.12.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.12.2 PURPOSE

To minimize the level of outdoor noise produced by the development.

2.12.3 CONTEXT

Noise emanating from the proposed development should not negatively impact the surroundings, including wildlife habitats and noise-sensitive buildings on-site or on adjacent sites. Minimizing the amount of generated noise, placing the noise-generating equipment in a suitable location on the site, and applying measures to prevent the dispersion of noise are some strategies that help mitigate noise pollution. The noise generated by buildings on site is generally due to building services systems (HVAC system, wind turbines etc.), wind-generated noise, building users' activities and vehicular site traffic

Noise-sensitive receptors include sites or buildings where the users are likely to be negatively affected by the noise generated by the new building or development. These may include residential, education, healthcare buildings libraries, places of worship, wildlife areas, parks or gardens.

Continuous operation of building services systems can affect the surrounding indoor and outdoor environment. Maintaining acceptable noise levels within these environments may require some acoustic treatment.

2.12.4 GUIDELINES

- Locate noise-generating equipment underground or away from the periphery of the site, especially if adjacent properties include noise-sensitive receptors
- Prevent the dispersion of noise to adjacent properties using noise control measures such as sound-baffling walls, fences, or trees to minimize the effects of noise pollution.
- Isolate or separate, through the design of the development site plan, building spaces that will accommodate noise-generating activities from any noise-sensitive receptors adjacent to the site.
- Consider the form and arrangement of proposed buildings when trying to reduce noise pollution generated from wind conditions on the site. The building's exterior elements can also generate noise from air movement; the form, material, and positioning of roofs, wall systems, louvers, and other exterior building elements may produce wind-generated noise and impact noise-sensitive receptors.
- Minimize the noise produced by on-site traffic through careful placement of roads and parking locations on the site.
- Avoid locating plazas, courtyards, pedestrian walkways, recreation areas, roads, and parking facilities near noise-sensitive receptors and use sound barriers and buffers where necessary.

FURTHER RESOURCES

Websites:

1. *ISO 1996-1:2003 Acoustics: Description, Measurement and Assessment of Environmental Noise- Part 1: Basic Quantities and Assessment Procedures*. International Organization for Standardization, 2003.

2. *ISO 1996-2:1987 Acoustics: Description, Measurement and Assessment of Environmental Noise- Part 2: Determination of Environmental Noise Levels*. International Organization for Standardization, 2007.

3. *ISO 1996-3:1987 Acoustics: Description and Measurement of Environmental Noise- Part 3: Application to Noise Limits*. International Organization for Standardization, 1987.

2.13 [S.13] ECO-PARKING

2.13.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.13.2 PURPOSE

To maximize the number of sustainable parking spaces in the development.

2.13.3 CONTEXT

Implementing efficient and sustainable parking strategies early in the design process can minimize the on-site parking footprint while adequately serving the needs of the development. Parking demand for a building or development should be based on its use and intensity. The industry standard methodology for parking distribution in many regions relies on the Institute of Transportation Engineers (ITE) Parking Generation Manual; however, ITE standards are based on observations of peak demand for parking at single-use developments in relatively low-density settings with little public transit. There is often a tendency to overestimate the actual parking requirements which would adversely impact the creation of a sustainable parking scheme.

Minimum parking requirements for new construction are usually established by international standards and the requirements vary based on typology with retail requiring the greatest number of parking spaces. Sustainable urban planning relies on noting and establishing the maximum parking requirements based on usage, transit options, demographics, and density. Higher density areas allow for reduced auto ownership as destinations are closer together and a greater number of places can be reached on foot and by bicycle.

2.13.4 GUIDELINES

- Consider parking strategies that can reduce the overall parking footprint and provide flexibility to meet changing demands.
- Implement structured and underground parking for the building to minimize the size and visibility of parking areas while increasing the walkability and vibrancy of the site.
- Provide shading, adequate illumination and porous ground surfaces to at-grade parking areas in the interest of public safety, mitigating the adverse effects of excessive rainwater runoff and ease of maintenance.
- Use shared parking areas for adjacent facilities to reduce the number of required curb cuts and enhance pedestrian access.
- Consider shared parking in areas that combine different zoning types, for example: office and residential, where parking spaces may be used at different times of the day.
- Use, if permitted by local regulations, on-street parking which reduces construction costs and parking footprint and helps to slow traffic and shield pedestrians.
- Ensure that access drives, internal circulation drives, parking areas, and walkways are designed to provide safety, convenience and accessibility for motorists and pedestrians.
- Consider, where feasible, the use of alternative space-saving mechanized parking systems.

FURTHER RESOURCES

Websites:

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2. *Online TDM Encyclopedia - Sustainable Transportation and TDM*. https://www.vtpi.org/tdm/tdm67.htm. Accessed 1 Sept. 2019.
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Publications:

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2. Institute of Traffic Engineers. *Traffic Engineering Handbook*. 7th ed., Wiley, 2016.
3. *Parking Spaces / Community Places: Finding the Balance Through Smart Growth Solutions*. Development, Community, and Environment Division, U.S. Environmental Protection Agency, 2006.
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6. Singelis, Nikos, et al. "Lots and Lots of Parking Lots." *Stormwater Solutions*, Feb. 2008.
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8. Stover, Vergil G. *Transportation and Land Development*. Institute of Traffic Engineers, 2002.

2.14 [S.14] MIXED USE

2.14.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.14.2 PURPOSE

To diversify the major occupancy uses within the development.

2.14.3 CONTEXT

Development that is designed to combine different uses and occupancies brings vitality to communities, improves quality of life, increases safety to streets and provides extra opportunities as the various uses can be readily accessed by more people. Mixed use developments will benefit the developer/investor, the public and the environment.

Active streetscapes create safer environments and communities for building occupants and pedestrians. For example, a building that contains offices and restaurants or retail will support an active streetscape as the building will be regularly utilized during and after office hours. Providing for many services and uses within the same building or development will reduce the need for transportation and encourage pedestrian activity, thereby minimizing impacts to the environment through vehicular emissions. Additionally, consolidating uses and shared services can reduce the building/development footprint and the need for new infrastructure, minimizing the impact on the environment and promoting a healthy lifestyle.

If planning for multiple major uses, the development should also consider the impact of traffic loads and on-site parking facilities on surrounding streets and intersections.

2.14.4 GUIDELINES

- Consider designing for a range of major uses within the development site to promote an active streetscape and minimize transportation use.
- Analyze the site and its relationship to adjacent properties to anticipate congestion and traffic issues that may arise from the new development, especially if the development will contain a diversity of services and attract many users.
- Ensure that various uses within the same building or development will not detract from one another or cause unhealthy competition.
- Review the proposed uses and ensure the required support facilities and arrangements for each major use are provided.

FURTHER RESOURCES

Websites:

1. "Institute of Transportation Engineers." *Institute of Transportation Engineers*, https://www.ite.org/. Accessed 29 Aug. 2019.
2. *Online TDM Encyclopedia - Sustainable Transportation and TDM*. https://www.vtpi.org/tdm/tdm67.htm. Accessed 1 Sept. 2019.
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Publications:

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2.15 [S.15] CONSTRUCTION PRACTICES

2.15.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

2.15.2 PURPOSE

To adopt responsible construction practices and mitigate the adverse impacts of on-site construction activities.

2.15.3 CONTEXT

Construction activities can often result in significant environmental impacts including construction waste taken to landfill or incineration, dust generation, noise pollution, CO2 emissions related to electricity generation and increased traffic congestion on nearby roads, water depletion and soil and waterways contamination.

GSAS-Construction Management (GSAS-CM) scheme provides a systematic approach for evaluating the sustainability impact of building or infrastructure projects over the course of the construction phase. The scheme assesses the aspects of the construction processes and on-site practices of that have a lasting sustainability impact; and, provides framework to perform measurements in line with normative standards and accepted practices and to consider which impacts the project can mitigate.

For a contractor it is possible to target selected categories and criteria to achieve desired GSAS star rating. In order to incorporate the targeted GSAS-CM framework categories and criteria and to outline how a construction project will plan human, organizational, and communication resources and processes to meet the requirements of targeted GSAS criteria, a GSAS Construction Management Plan (GSAS-CMP), shall be developed by the contractor. GSAS-CM framework is based on eight categories including Urban Considerations [UC], Site [S], Energy [E], Water [W], Materials [M], Outdoor Environment [OE], Socio-Cultural Dimension [SD] and Management & Operations [MO]. The categories are then broken down into specific criteria that measure and define individual issues related to environmental aspects.

2.15.4 GUIDELINES

- Develop and implement strategies to reduce the adverse impacts from on-site construction activities as outlined in GSAS Construction Management Guidelines & Assessment manual.
- Register the project for obtaining GSAS-CM certification, with the targeted rating, during the construction phase.
- Refer to GSAS Construction Management Guidelines and Assessment for guidance on the requirements to meet the criteria objectives and obtain GSAS-CM certification.

FURTHER RESOURCES

Websites:

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24. *Source Water Protection Practices Bulletin: Managing Stormwater Runoff to Prevent Contamination of Drinking Water*. Office of Water, U.S. Environmental Protection Agency, 2001.

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3.0 ENERGY

The Energy category is concerned with improving the design and energy performance of the development having a direct and positive impact on both the consumption of resources and environmental quality including climate change, fossil fuel depletion, air pollution and human comfort, health and well-being.

Sustainable energy design helps to mitigate such impacts and contributes to a less energy intensive economy and a more sustainable environment.

There are multiple elements and factors which impact the total building energy consumption. They range from building envelope elements to HVAC system components. None of these factors can be looked at in isolation; only the calculation of the overall outcome will show the effectiveness of the design.

GSAS introduces the Energy Performance Coefficient or EPC. It is a quantified measure for understanding how well a building design performs in terms of energy use compared to a baseline design. EPCs have been introduced at three levels of design: the building, associated systems, and the supply network. This leads to the definition of EPC_{dem} (thermal energy demand performance), EPC_{use} (energy use performance), EPC_{pri} (primary energy performance), and EPC_{CO2} (CO_2 emissions reduction performance).

EPC_{dem} is a measure for comparing the effectiveness of the site selection and major building and envelope parameters in removing internal loads and shielding against the outside environment, while maintaining the required indoor comfort.

EPC_{use} is a measure for comparing the effectiveness of the designed building systems in meeting the energy needs of the building.

EPC_{pri} is a measure for comparing different energy delivery systems on and to the site taking the supply network into account.

EPC_{CO2} is a measure of the reduction of CO_2 emissions of the building delivery systems and energy supply network.

All EPC measures are based on normative, standardized calculations of outcomes (energy use as designed), divided by a reference value for a given building type.

Analogously, in the GSAS scoring method, the lower the energy performance (the lower the EPC value), the higher the resulting GSAS score.

Building energy demand on subsystems, such as HVAC, lighting, and power, can be reduced by an integrated design that minimizes building loads by selecting an appropriate site and making good selections in building system types and their sizing. These guidelines provide recommendations for design teams to meet the imposed limits on energy use with pointers on the standard calculations that must be conducted to demonstrate compliance. The most important design parameters of buildings that should be addressed are the following:

Building Site Selection:

- Site Location
- Site Orientation

Building Envelope:

- Building Footprint
- Roof
- Walls
- Floors
- Slabs
- Doors
- Windows
- Skylights

Building Internal Load:

- Lighting Load
- Appliance Load
- Occupancy Load

HVAC Systems and Equipment

- Cooling System
- Chillers
- Cooling Towers
- Chilled Water Pumps
- Condenser Water Pumps
- Heat Exchangers
- Pipes, Connections and Valves
- Condensing Units
- Cooling system insulation

Heating System:

- Boilers
- Heat Exchangers
- Hot Water Pumps
- Pipes, Connections and Valves
- Electric Heaters
- Heat Pumps
- Heating system insulation

Ventilation System:

- Air Handling Units
- Fan Coil Units
- Intake & Exhaust Fans
- Ducts, Outlets, Connections and Dampers
- Air system insulation
- Controls:
- Control System
- Control Strategies

Making the correct decisions concerning the above elements will result in a more sustainable development that consumes less energy. Additionally, factors that could mitigate environmental impacts due to energy use include: designing to lower energy demand; selecting efficient systems; lowering the demand on nonrenewable sources of energy thereby reducing harmful emissions and depletion of fossil fuels; and minimizing the amount of harmful substances produced by the energy delivery systems and the energy supply network. In the following sections, guidelines and considerations for making these decisions are provided.

CRITERIA IN THIS CATEGORY:

E.1 Thermal Energy Demand Performance

E.2 Energy Use Performance

E.3 Primary Energy Performance

E.4 CO_2 Emissions

E.5 Energy Sub-Metering

E.6 Renewable Energy

3.1 [E.1] THERMAL ENERGY DEMAND PERFORMANCE

3.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

3.1.2 PURPOSE

To minimize the building energy demand through the establishment of GSAS thermal energy demand performance.

3.1.3 CONTEXT

EPC_{dem} is responsive to changes in the building site, building envelope and orientation, as well as internal loads in the building. Improving any of these factors will have a positive impact on EPC_{dem}.

Major attention should be given to the building envelope such as the placement of windows and the building envelope U-values. The choice of shading, solar reflection, and other measures to reduce the solar heat gain factors have the greatest effect on reducing the predominant energy consumption for cooling.

3.1.4 GUIDELINES

Building site selection

- Select a site where the adjacent buildings or landmarks can provide shading without negatively affecting access to daylight.
- Ensure that the orientation of a building is considered during planning as it determines the duration of sun exposure on windows and other surfaces of the building. Figure 1 shows that in Qatar, the optimum orientation is close to but slightly East of due South, centered at 172.5°, clockwise from North.

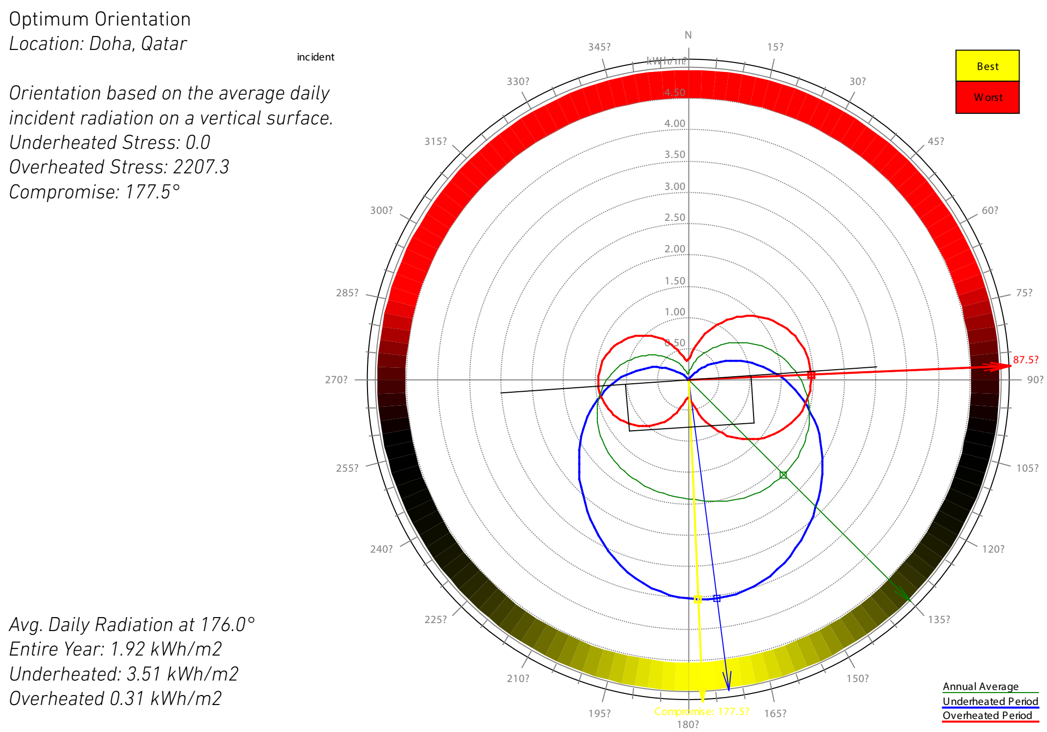

Figure 1: Optimum Building Orientation in Qatar

Building envelope

- Specify envelope elements with low U-values (high R-values) to reduce both solar and conductive heat gains and losses. Baseline recommendations for selecting the U-Values of envelope elements can be found in ASHRAE 90.1 for different climatic zones. Reference Figure 2 below for an example of heat transfer through a typical wall.

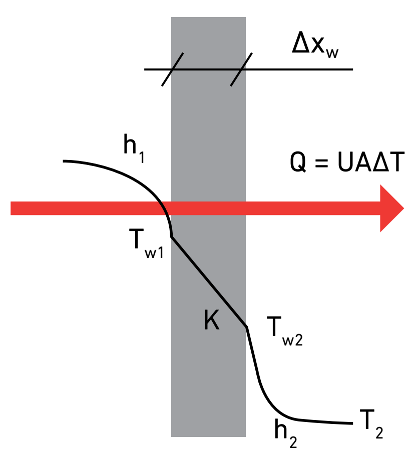

Figure 2: Heat Transfer Through Typical Wall

- Specify all windows and skylights with low Solar Transmittance to control solar gain and reduce cooling load. Baseline recommendations for selecting the Shading Coefficient of windows and skylights can be found in ASHRAE 90.1 for different climatic zones.
- Design a building with a minimum number of windows on the west, east, and south orientations.
- Design a building with a maximum number of windows on the north orientation to benefit from indirect daylighting. Reference Figure 3 below for an example of top and side daylighting.

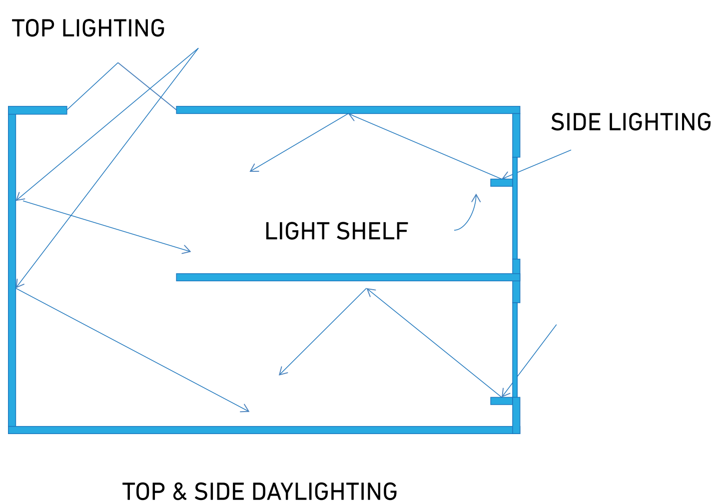

Figure 3: Top & Side Daylighting

- Design the building with the minimum acceptable quantity of windows, especially those oriented towards the west.
- The following charts are tailored specifically for Qatar and show the effects of total monthly transmission and solar heat gains on one square meter of opaque or glazing surface for the four orientations. The charts depict the effect of installing two different building materials (different U-value and solar transmittance).

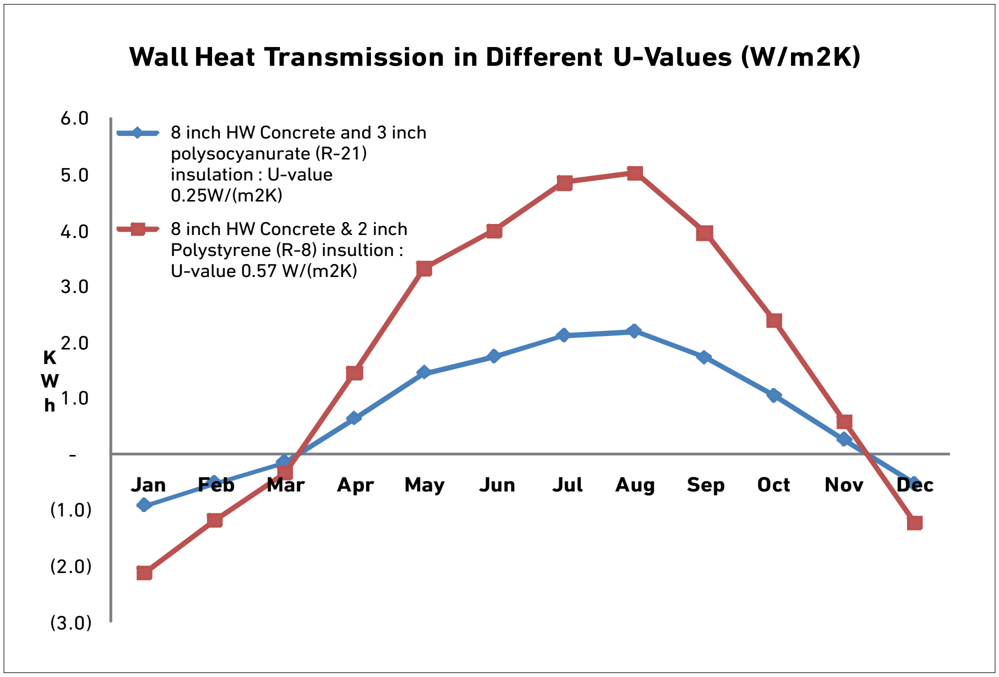

Figure 4 Wall Heat Transmission in Different U-Values (W/m²K)

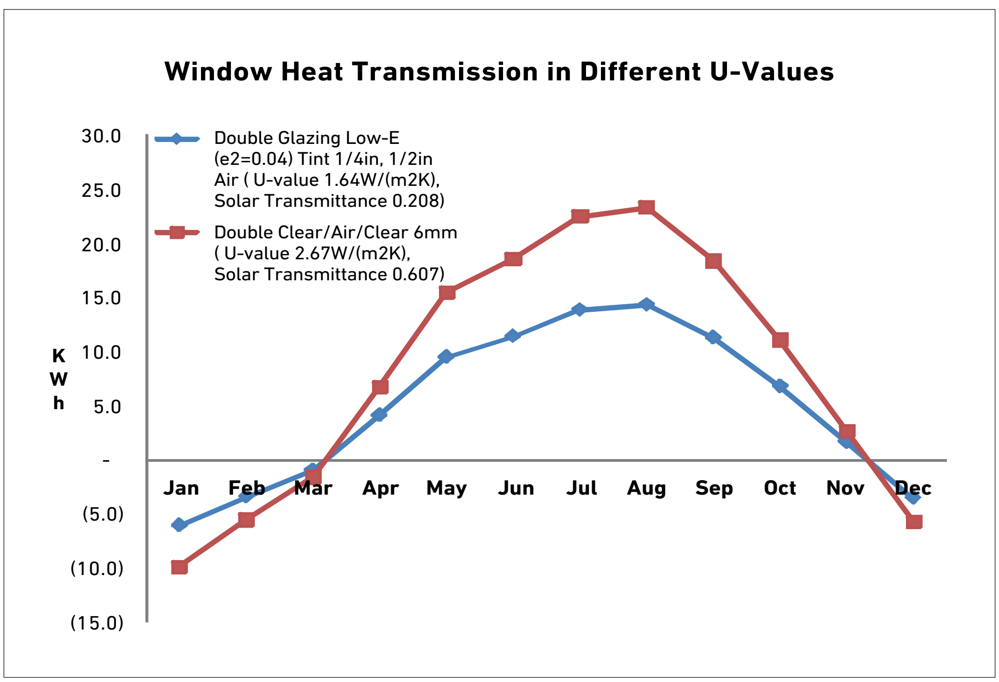

Figure 5 Window Heat Transmission in Different U-Values (W/m²K)

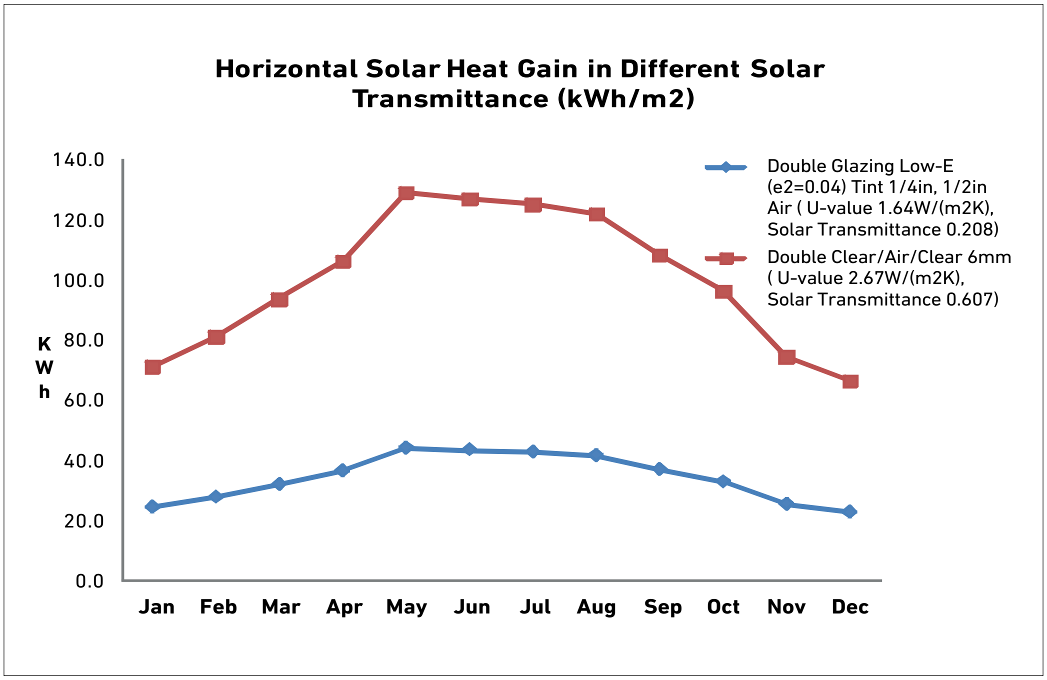

Figure 6 Horizontal Solar Heat Gain in Different Solar Transmittance (kWh/m^2)

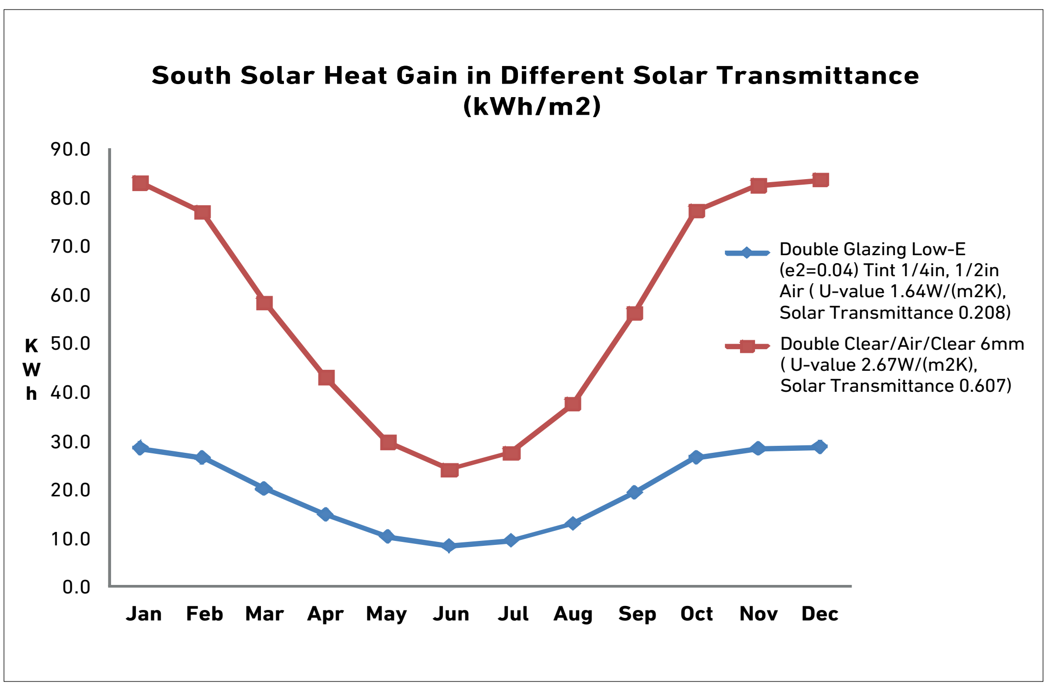

Figure 7 South Solar Heat Gain in Different Solar Transmittance (kWh/m^2)

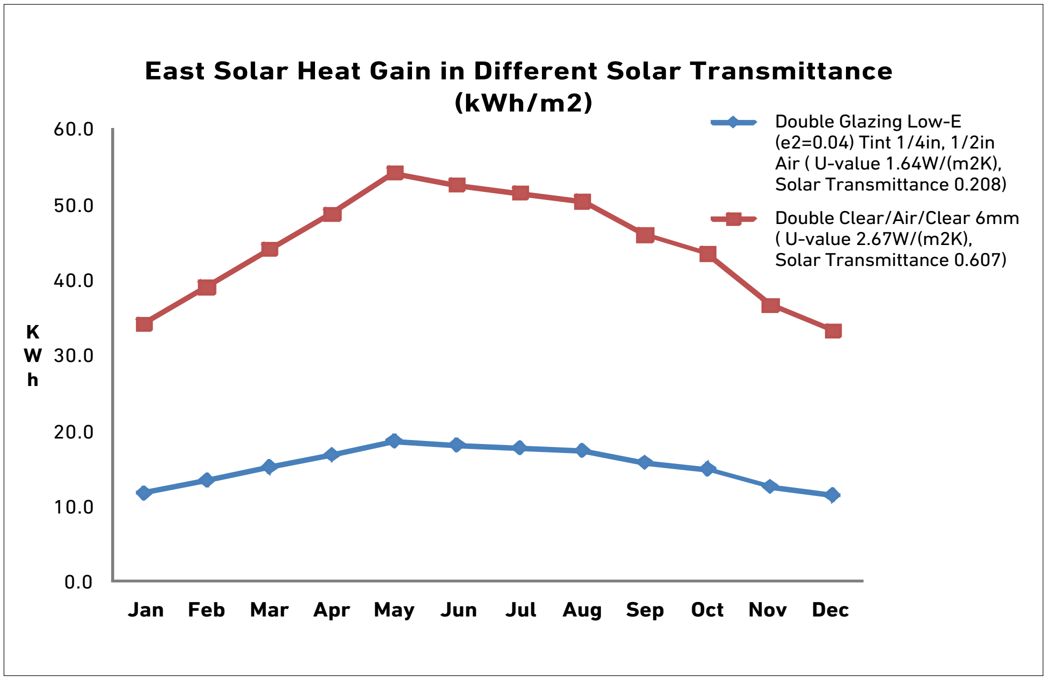

Figure 8 East Solar Heat Gain in Different Solar Transmittance (kWh/m2)

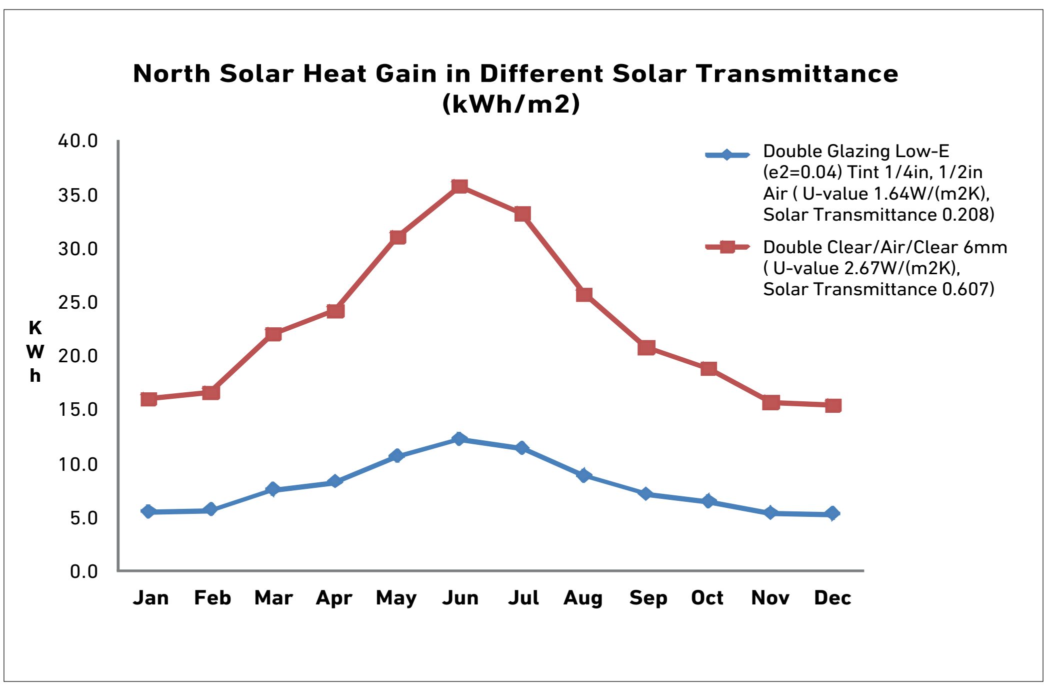

Figure 9 North Solar Heat Gain in Different Solar Transmittance (kWh/m^2)

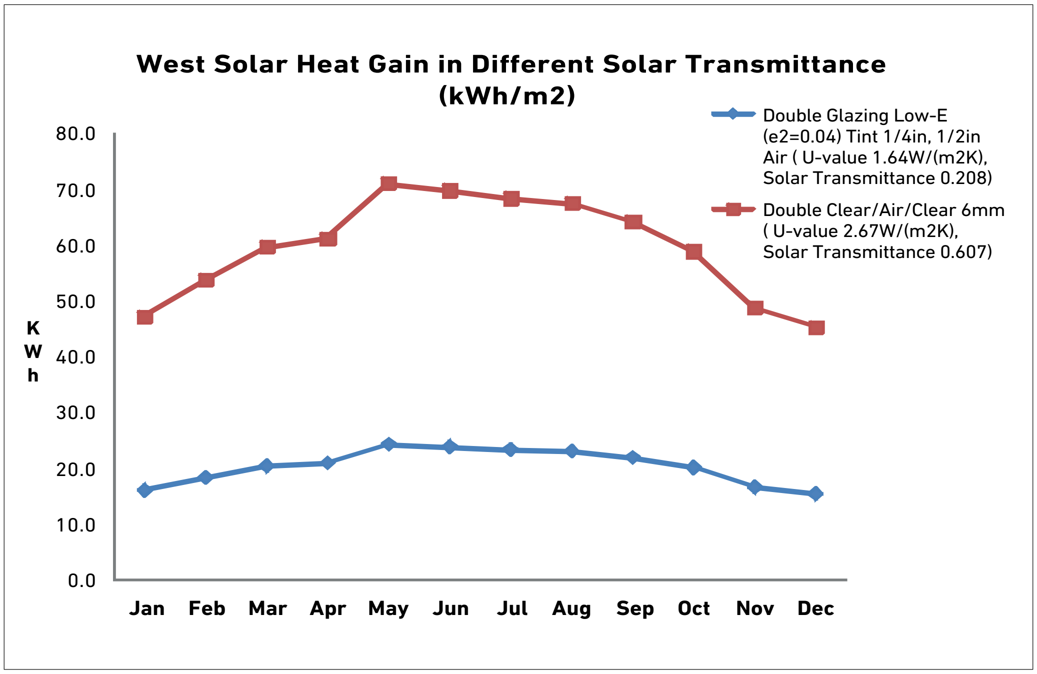

Figure 10 West Solar Heat Gain in Different Solar Transmittance (kWh/m²)

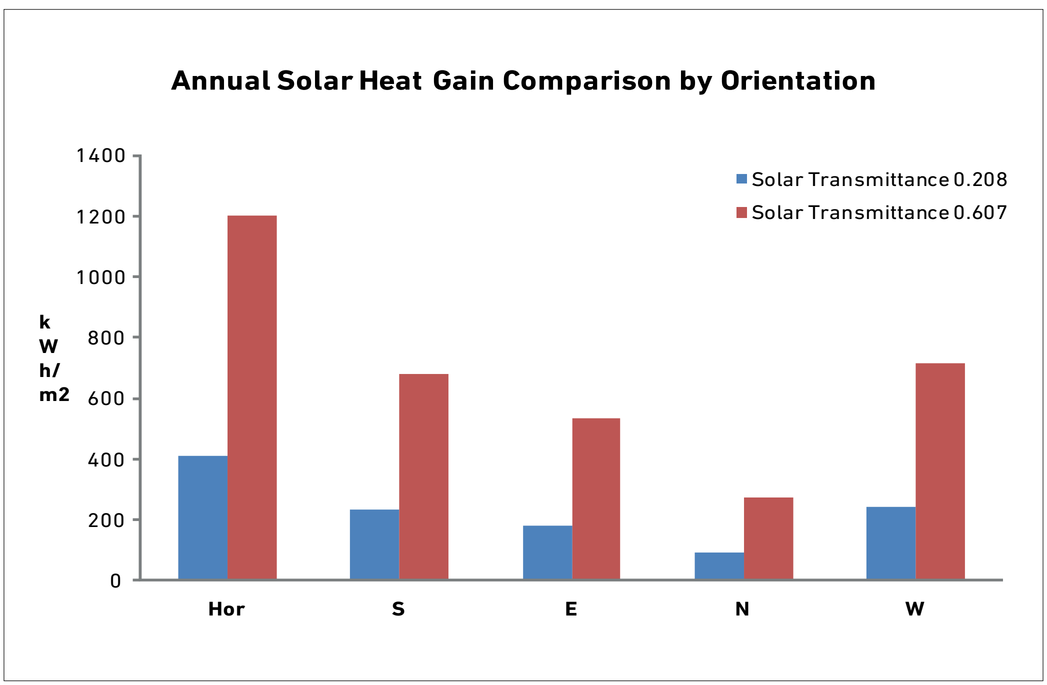

Figure 11 Annual Solar Heat Gain Comparison by Orientation (kWh/m²)

- Utilize passive solar design considerations. Reference Figure 12 below for an example of passive solar design.

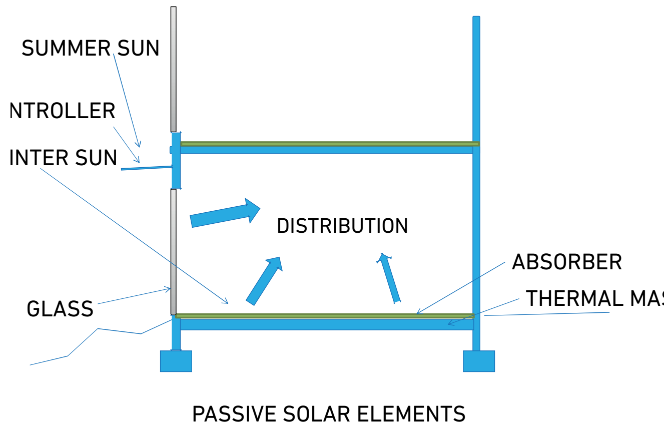

Figure 12 Example of Passive Solar Design

- Increase roof surface reflectance and emittance using reflective paints, materials or coatings.
- Avoid specifying louvers on the side of the building facing high wind pressure in order to reduce the chance of introducing uncontrolled and unconditioned outside air into the building.
- Specify all the joints around the windows, skylights, and doors, as well as junctions between walls and other structural elements, to be built airtight to minimize air leakage rates.
- Specify all the walls, floors, and chase penetrations with pipes and ducts to be filled with the proper material. Proper material specification will minimize the rate of air leakage occurring between the pipe/ duct exterior and the penetration opening.
- Specify vapor retardant on all the exterior structural elements to prevent humidity from entering or leaving the building.
- Use hybrid ventilation strategies, such as providing operable windows, where possible. If such strategies are used, pay particular attention to temperature and humidity control in the conditioned spaces. The entry of unconditioned and uncontrolled outside air into the building should be monitored and system provisions should be made to safeguard against inefficiencies and condensation. A thorough analysis shall be conducted before specifying operable or non-operable windows or other hybrid ventilation strategies, such as system controlled operable windows, or novel strategies to mix “non-pressurized” system ventilation with natural ventilation.
- Provide fly fans or roll-up doors at entrances to the building, such as loading docks, to prevent unconditioned, uncontrolled outside air from entering the building.

- Insulate pipes, ducts, plenums, and cold or hot equipment with the proper insulation types and thickness. Insulating pipes beyond the critical ratio will actually increase the quantity of heat transfer from the pipe.
- Provide an air-tight vestibule for the main building entrance to prevent large amounts of unconditioned air from entering the building.
- Provide overhangs for facades on buildings facing south, and adjustable customized fins for windows facing west and east to decrease the amount of solar heat entering the space.
- External shading devices protect the building against excessive solar gains during the summer but may have negative and positive effects on daylighting during the year. A daylight analysis should be used to show how positive effects can be maximized and glare can be minimized.

Building internal loads

- Design outside air quantity based on real occupancy of the building. Do not over-estimate the number of people in the building. For a comfortable and hygienic indoor environment, a minimum ventilation rate is needed when the building is occupied, typically 0.3 * V [m^3/hr], where V is the ventilated volume, in m^3 for residential buildings, and 30m^3/hr/person for non-residential buildings during occupancy period.
- Use daylighting provisions to decrease the minimum required energy intensity of lighting. This decreases the size of the equipment and their associated ballast. However, when daylighting is utilized to reduce lighting electricity, the solar heat gain through glazing should be controlled, and in addition, glare and contrast must be controlled to provide a comfortable indoor environment. Daylights from skylights in North-facing zones are optimal.
- For example, corridors in educational buildings are generally excellent spaces for daylighting. Overhangs should be positioned over the daylighting aperture and can possibly be sized with the light shelf to prevent direct sun from entering the space, especially during occupancy hours. Additionally, for office buildings, lower furniture in open plan office areas increases the efficiency of both the daylighting and the electric lighting system by reducing absorption and unwanted shadows. In office work areas, electric lights should be dimmed continuously rather than controlled manually in response to daylight to minimize employee distraction.
- Use task lighting and occupancy sensors to decrease the local lighting load. The use of occupancy sensors with manual-on and automatic-off control in day lit spaces, such as classrooms, offices, mechanical rooms, and restrooms, saves lighting energy. Also, the use of local articulated task lights (desk lamps that can be adjusted in three planes) in day lit spaces increases occupants' satisfaction.

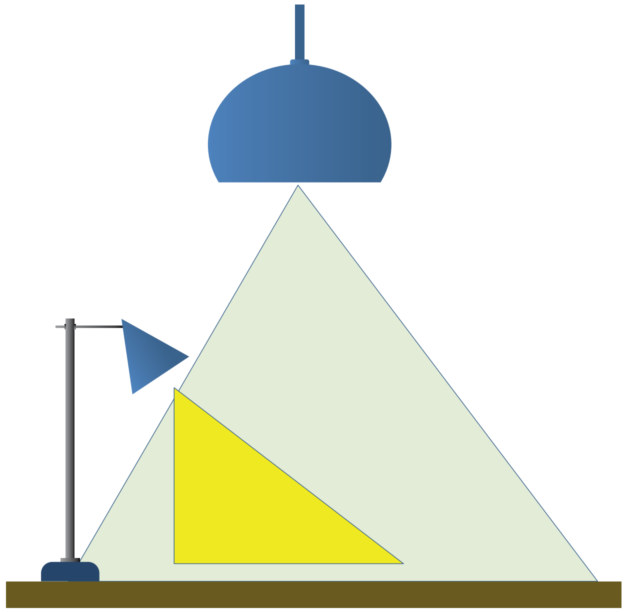

Figure 13: Use of Task Lighting to Decrease Local Lighting

- Specify more efficient interior lighting. The widespread availability of compact fluorescent lamps and LED (light-emitting-diode) lighting options should reduce lighting electricity consumption and heat gains.
- Apply methods of total light management, where external solar shading, internal shading, and electric lighting are controlled in a holistic manner.
- Specify more energy efficient appliances to reduce the electricity requirements of plug loads and reduce heat gains from the usage of appliances, office equipment, and other devices plugged into electrical outlets.

3.2 [E.2] ENERGY USE PERFORMANCE

3.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

3.2.2 PURPOSE

To minimize the building energy use through the establishment of GSAS energy use performance.

3.2.3 CONTEXT

EPC_{use} is a building performance indicator that is sensitive to the changes in a building's HVAC systems and other equipment.

3.2.4 GUIDELINES

HVAC systems controls

Implementing control techniques when using on-site cooling generation equipment, such as chillers is necessary, for example: variable volume flow, primary/secondary pumping, frame-and-plate heat exchangers use for water-side economizer or use of chillers with de-superheating availability for use of wasted heat in chillers to warm-up any domestic water heating (in cases where this is required).

- Use either an airside or waterside economizer which provide options for large energy savings. However, in a humid climate, the investment in a waterside economizer may not be a viable choice because weather conditions are not suitable for the operation of a waterside economizer. On the other hand, an airside economizer requires the means to treat large amounts of outside air introduced into the building through the economizer cycle. This by itself can be a major source of unwanted air leakage during regular operation of the system. For these reasons, a detailed study should be conducted to justify the use of the economizer cycle in the development.
- Use variable-speed-driven secondary pumps. This reduces pump energy by allowing each pump to operate at total system head. This also improves balancing of the system and creates better part load performance.
- Design and specify equipment based on operation near their maximum efficiency performance levels based on manufacturer data.
- Use an energy recovery system to recover the heating or cooling from the exhaust air before discharging it to the outdoors.
- Use variable air volume systems to reduce the chance of over-cooling or over-heating a

space when it is not at its peak load conditions. For particular applications, constant volume systems, for example fan coil units, can be used to provide better performance. Such systems are more efficient due to their smaller size, multiple units, and limited control requirements. Before selecting a system, a study must be conducted to specify which type of system is more appropriate for the specific application.

- Avoid using temperature sensors that can be readjusted locally.
- Use the maximum practical size of ductwork with a minimum number of elbows and direction changes. This will reduce the air pressure loss inside the duct and therefore, minimize the required fan power for pushing air through the ducts.
- Ensure that spaces that require continuous conditioning, such as electrical rooms or data centers, are served separately from the rest of the building. This will eliminate the inefficient use of equipment in serving small, specific spaces when there is no demand for the rest of the building.
- Use direct digital control systems to optimize start-up or shut-down of the systems.
- Provide provisions to use wasted heat through boilers, if applicable, and water heaters' flue stacks for pre-heating water and air. However, this is typically not relevant in Qatar where no heating is required.
- Specifying HVAC systems capable of supplying the appropriate amount of outside air ventilation to the building, to provide a comfortable environment for occupants. Since this factor defines a major part of the load, particular attention should be paid to the design to provide the proper amount of outside air ventilation to the building. Excessive amounts of outside air will result in a high level of energy consumption, while a deficiency of outside air will make the building unhealthy and undesirable for the occupants.

Optimizing chiller design:

Energy cost of a chiller plant depends on different variables such as: full load and part load efficiency of elements (chillers, pumps, cooling towers, etc.) of the chiller plant, design (variable flow or constant flow) and staging of the equipment, control sequencing and piping design. The ideal solution is to optimize all the elements at the same time, but it is not practical or possible to optimize all the elements simultaneously because of their interaction with each other.

- Select for a district cooling plant serving a group of large loads, such as campuses with multiple buildings, a *Distributed Variable Speed Driven Secondary Pumps (DVSDSP)* system (dedicated variable speed pump to each building) is the most efficient system. This is because it allows each secondary pump to be installed and to operate at system head required from the plant to the specific building, while in a conventional primary-secondary type chilled water system, a control valve is needed to throttle the pressure and distribute uniform pressure to the near and far loads. Using DVSDSP also improves performance in part load conditions.

- Select control sequences for energy savings to minimize the energy use of the *Stage Chillers & Pumps.* Using variable speed chillers and pumping systems will ensure that the system efficiency does not drop until the load is down to about 20-25% (dependent on specific manufacturer's data). Strategies to help the efficiency of the system include the following:

  - For a single speed chiller/pumping system, it is more efficient to operate using only the minimal number of chillers necessary to satisfy the load. If the system operates with more chillers than needed to satisfy the load, the system will perform at lower efficiency.
  - For a variable speed chiller/pumping system, it is more efficient to operate as many chillers as possible. Multiple chillers at lower loads perform better than a single chiller at near full load. Variable speed chillers make the staging process less complicated.
  - For primary-secondary pumping systems, it is more efficient to start the chillers one by one to ensure that there is more primary chilled water than secondary chilled water in the loops.
- Use the plant Direct Digital Control (DDC) system to start/stop chillers and use chiller controls (not the plant DDC system) to start/stop primary pumps to ensure additional energy savings.
- Minimize the energy use through *Chilled Water Temperature Reset:* Chillers are more efficient when the departing water temperature is higher. Increasing the chilled water temperature difference from the conventional 4-5 degree Celsius to as high as 10-11 degrees Celsius, decreases the required water capacity and therefore, decreases the size of the pumps and as a result, the motor power to run the pumps. A higher chilled water temperature difference causes higher airside pressure to drop and higher fan energy consumption, while simultaneously decreasing the waterside pressure drop and as a result, the pump energy consumption drastically. A typical result of temperature changes on air and water pressure drop can be seen in Table 1:

Effect of Chilled Water Difference on Coil Pressure Drop			
Chilled Water Temperature Difference [°C]	5	8	10
Coil Water Pressure Drop, [kPa]	90	42	24
Coil Airside Pressure Drop, [kPa]	1.4	1.46	1.52

Table 1 Effect of Chilled Water Difference on Coil Pressure Drop

- Minimize the energy use through the control of *Thermal Storage.* This system offers higher energy cost savings when the energy cost is different during the day and night.

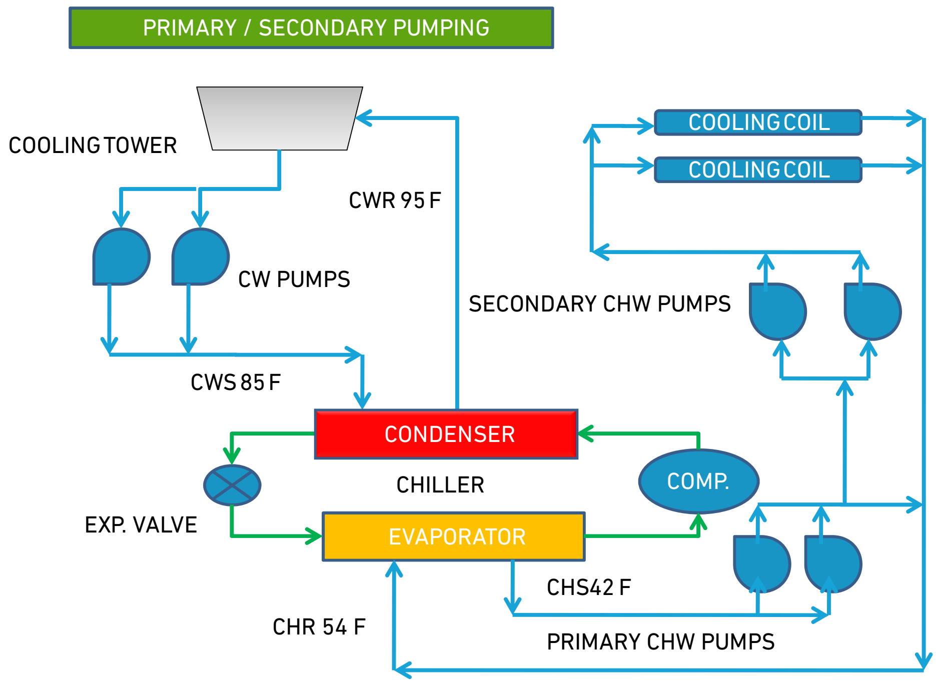

Figure 14 Primary/Secondary Pumping

- Select valves for energy savings to minimize the energy use of a piping system. Use ball valves or butterfly valves for insulation and balancing purposes, since both valves offer low pressure drop. Do not install a strainer upstream from the coil to protect the control valve, because they usually generate flow problems. Strainers at the pump usually perform the required job and are very accessible.
- Design the coil temperature difference about 2 to 3 degrees higher than the plant temperature difference (the water from the district cooling system) to account for coil heat transfer degradation.
- Divide the floor plans into exterior and interior zones with HVAC systems serving each zone individually with its own temperature and humidity sensors, if applicable.
- Provide motorized dampers for stairs and elevator shafts to reduce the chance of wasting conditioned air through these openings.
- Provide motorized dampers for all intake and relief/exhaust louvers and vents to protect the conditioned air from leaving the building and prevent unconditioned outdoor air from coming into the building.
- Do not provide freeze protecting devices for exterior pipes; but if so, they should be shut off permanently.

- Install cooling towers, chillers, and boilers and their associated pumps on the top floor of the building to decrease the required additional pump head and therefore, reduce the required motor power.
- Use a multiple number of smaller chillers, instead of one or two large ones, to help the systems work most of the time around the full load situation and therefore, have greater efficiency.
- Use condensate drain recovery from air handling unit coils to use for and reduce required cooling tower make up water or other water usages in the building.
- Use fan powered terminal units to reuse the plenum heat in controlling the temperature of the space.
- Use electrical finned tube radiation elements to protect large/tall lobby glasses.
- Use, in high-rise buildings, multiple mechanical floors and multi-stage plate heat exchangers/ pumps to reduce the required pump motor power.
- Use flow measuring stations at outdoor air intake to the air handling units to control the quantity of the outdoor air.
- Use, where possible, one or more of the following design options to improve the efficiency of the system: primary-secondary pumping, ice storage, cogeneration, coil loop for exhaust air energy recovery, total energy recovery wheel, and direct or indirect evaporative cooling.
- Use, where possible, one or more of the following control strategies to improve the efficiency of the system: chilled and condenser water reset, fan cycling, demand limiting, duty cycling, and fan pressure optimization at part load operation.
- Use condensing type boilers (if applicable) and domestic hot water heaters to increase the heat generation efficiency from the conventional 80% to up to 95-98%. In Qatar, this will only be appropriate in special circumstances where a heating system is required.
- Electric centrifugal chillers have one of the highest efficiency ratings among other chillers. Use centrifugal chillers or other high efficiency chillers to increase the chiller efficiency to as high as 0.5 kW/ tons.
- Provide, where the chilled water piping volume relative to the chiller capacity is small, an inertia tank to protect the chiller operation against extreme on-off cycling.
- Use innovative on-site energy generation methods, such as photovoltaic cells, to decrease the consumption of energy from public utility sources.
- Provide provisions and connections for selling the additional on-site generated electricity to the city network, where building demand is satisfied but the city has additional demand.
- Provide dedicated controlled exhaust systems for copy rooms to exhaust air from the room only when the copiers are functioning.

- Provide adequate air intake space for outdoor air-cooled equipment, such as cooling towers, to let them operate at the highest efficiency rating.
- Prevent stratification of return air and outside air within the mixing box to improve the air handling unit efficiency.
- Use chillers with de-super-heating ability or a heat exchanger to extract wasted heat from the chiller; and pre-heat the domestic hot water before entering hot water heaters, as illustrated in Figure 15 below.
- Specify and enforce commissioning supervision for implementing all the above-mentioned improvements during the design phase.

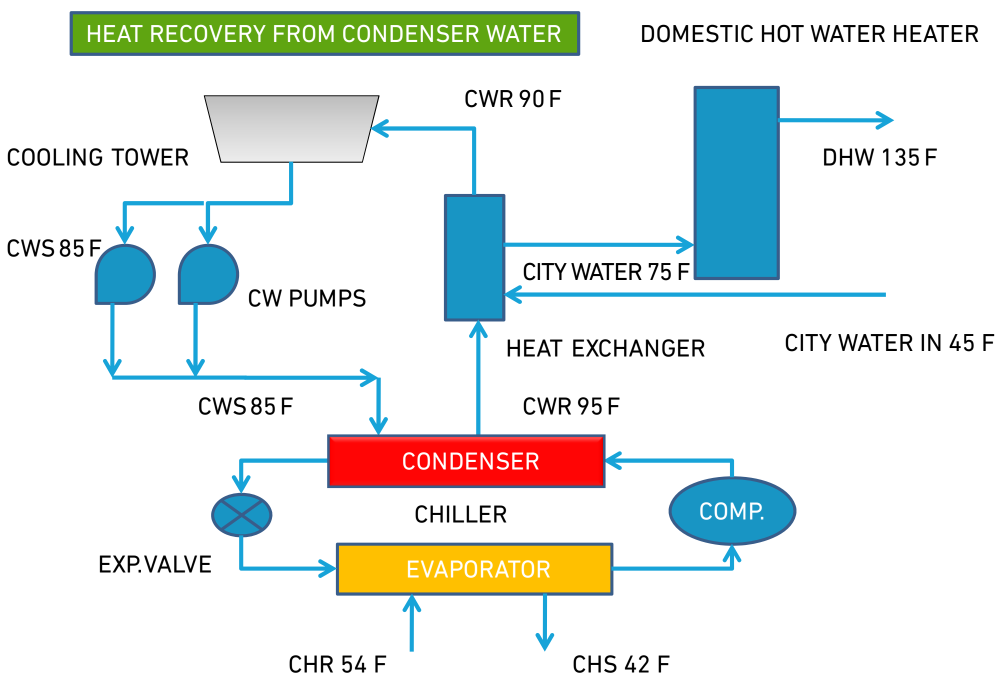

Figure 15 Heat Recovery from Condenser Water

A typical high-rise building was studied considering the local climate conditions in Qatar, with different HVAC systems as presented in Figure 16. The graph displays the relevant gains that result from different system choices. The most energy efficient system is the system with purchased district cooling. The DX packaged variable volume and air-cooled chiller systems are about 10% less efficient. The other systems are 15-30% less efficient.

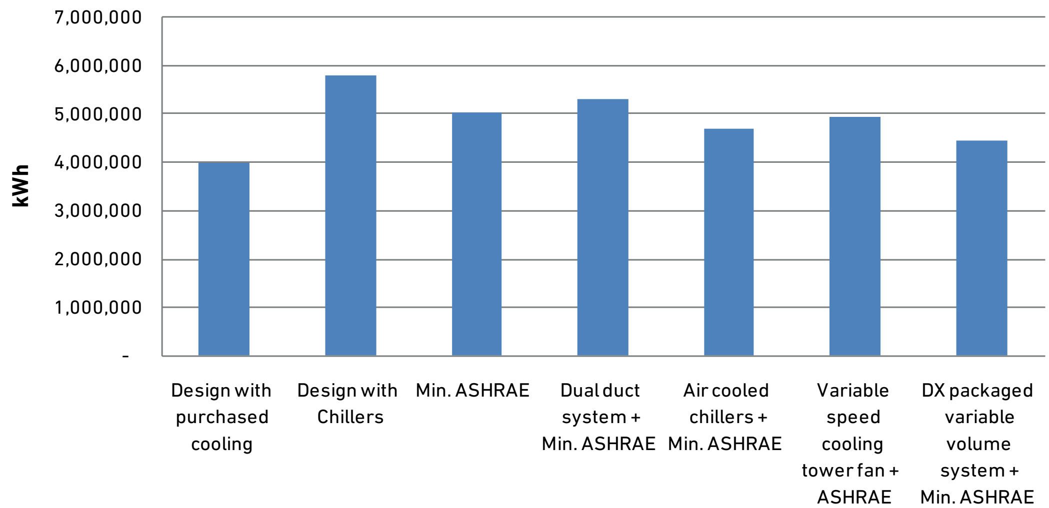

Figure 16 Different HVAC System Comparison

3.3 [E.3] PRIMARY ENERGY PERFORMANCE

3.3.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

3.3.2 PURPOSE

To reduce the dependence on fossil-based primary energy supply and delivery network through the establishment of GSAS primary energy performance.

3.3.3 CONTEXT

The energy performance coefficient for primary energy sources (EPC_{pri}) is a performance indicator sensitive to changes in the method of energy delivery. It is subject to different types of energy delivery, using different types of energy supply networks including electricity, gas, and district cooling. These factors are largely dependent on the city infrastructure and in the region the prevalent networks are electricity from large, gas-fired power plants and chilled water delivery by district cooling plants.

3.3.4 GUIDELINES

- Use the primary energy factor (PEF) after calculating the consumed energy at the building site to account for the efficiency of producing and delivering different types of energy to the site. For countries where the natural gas is used as the main source of electricity generation, which is delivered to the doorstep of a building the PEF is calculated as follows:
    - Assume a 15% loss for extracting gas from the ground, a 55% loss for converting gas to electricity, and a 10% loss for delivering the electricity to the building site. These numbers are completely based on how the infrastructure is designed in different countries, and a detailed study will have to be performed to determine usable numbers. For example, the PEF would then be calculated as (1-0.15) * (1-0.55) * (1-0.1) = 34.4%. Another example for the calculation for purchased chilled water depends on both chiller coefficient of performance (COP) and electricity resource utilization factor. Therefore, for a chiller with COP of 4 and 30% electrical resource utilization factor, the purchased chilled water resource utilization factor will be (4) *(0.30) = 120%.
    - These numbers only provide indicative figures. Specific PEFs for energy carriers of electricity and thermal energy for any country must be calculated using local data.

3.4 [E.4] CO_2 EMISSIONS

3.4.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

3.4.2 PURPOSE

To establish CO_2 emissions performance associated with the primary energy supply and delivery network.

3.4.3 CONTEXT

The energy performance for CO_2 emissions (EPC_{CO2}) is a performance indicator sensitive to changes in the method of energy delivery. It is subject to different types of energy delivery, using different types of energy supply networks including electricity, gas, and district cooling. These factors are largely dependent on the city infrastructure and in the region the prevalent networks are electricity from large, gas-fired power plants and chilled water delivery by district cooling plants.

3.4.4 GUIDELINES

- Use CO_2 emission coefficient to estimate the impact of emissions from the energy delivered. Emission coefficients are factors to measure emissions resulting from the primary resource inputs during fuel combustion at power plants. They vary depending on the type of resources used for electricity generation and the type of delivered energy as secondary energy from power plants. Emission coefficients represent the combination of conversion inefficiencies and the transmission and distribution losses from the generation sources to the point of use. The conversion inefficiencies include the effects of pre-combustions, which are associated with extracting, processing, and delivering the primary resources to the point of conversions in the power plant or directly in the building. The EPC_{CO2} value can be improved to have less emitting power supplies (which have less emission coefficient value) as an example introduced in the EPC_{pri} improvement.

3.5 [E.5] ENERGY SUB-METERING

3.5.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

3.5.2 PURPOSE

To install sub-meters for monitoring the major energy consuming systems.

3.5.3 CONTEXT

The use of energy submetering in buildings generates awareness of energy conservation among users including landlords and tenants as they will be aware of the exact consumption profile and costs associated with their behavior.

Energy sub-metering will also facilitate the development of strategies to help improve performance, thereby ensuring the overall efficiency of systems operations. In addition, Users can apply consumption data to implement conservation or renovation projects to lower usage & costs and meet government regulations.

Sub-metering devices are installed to monitor and evaluate energy performance and consumption during the building operations phase. Major energy systems should be metered and monitored in conjunction with data logging to enable continued accountability of energy consumption over the lifespan of the development. Consumption data provides users with the information to locate high-consumption areas.

3.5.4 GUIDELINES

- Provide monitoring devices that display and record the energy consumption data of major systems in the building.
- Provide energy sub-meters for all major energy-consuming systems, such as lighting, hot water heaters, boilers, fans, cooling, humidification, space heating, competition-related equipment, large-scale broadcast and media systems, equipment associated with industrial processes, and large-scale food service equipment.
- Ensure the energy sub-metering is properly and clearly labeled, easily accessible and convenient for regular access by the facility operators.
- Specify the appropriate location of energy sub-meters, for example in the plant room, distribution room, or control room.
- Determine the optimal quantity and specific locations of energy meters according to the types and complexity of systems to be monitored.
- Consider utilizing energy simulations or engineering analysis to predict overall energy consumption and evaluate major energy system performance.
- Determine measures and strategies for continued improvement of energy efficient building operations, throughout the design of the development and during the operational phase of the development.

3.6 [E.6] RENEWABLE ENERGY

3.6.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

3.6.2 PURPOSE

To install on-site renewable energy generation systems.

3.6.3 CONTEXT

The use of renewable energy reduces the use of primary fossil-based energy sources, thereby reducing the associated environmental footprints. Using photovoltaic cells to generate electricity can be an effective method for the generation of onsite electricity. PV cells are sources of renewable energy that convert the energy directly into electricity using semiconductors. PV cells produce a direct current, which needs to be converted to an alternating current before it can be used in buildings. The common technique is to store direct current from PV cells in batteries and change it to an alternating current using an inverter. The major advantage of an alternating current created by the inverter is that the alternating current is compatible with the city utility grid. If the local PV system can generate additional electricity, the excess electricity can be transferred to the main utility grid and sold to the city electric provider, specifically when the city grid experiences high demand from customers during certain times of the day.

Similarly, solar water heating and thermal or electrical energy generation using other renewable sources such as mini wind mills, renewable biomass or geothermal sources help to reduce the environmental impact of primary fossil-based energy.

The best use of renewable systems is to generate electricity, for example, using Photovoltaic (PV) panels or wind turbines. PV cells are sources of renewable energy that convert sun energy directly into electricity using semiconductors.

3.6.4 GUIDELINES

Solar energy and photovoltaic (PV) cells

- Use solar energy systems passively or actively to supply part of the building heating needs.

Figure 17 Photovoltaic Panel

- Manage PV system installation in the development.
- Store currents from PV cells in batteries and change it to an alternating current using an inverter.
- Transfer the excess electricity to the main utility grid, if the local PV system can generate additional electricity.
- For early dimensioning purposes the following simple calculation process can be used:

Using renewable on-site energy:

Roof size available: ~1,000m^2

Area of each PV cell: 1.5 m^2

Number of PV panels: 625

Max. output of each PV panel: 200 watts

Max. PV panels: 125 KW

PV voltage: 270

Estimated number of modules in series: 10

Modules in parallel: 62

Peak Amps of each module: 7.5

Total Amps from PV panels: 465

Average sun per day in Qatar: 8

AMP-hour per day: 3720

Watt-hour per day: 1004400

Load Correction Factor: 1.1

Power daily requirement: 910 kWh/day

In this case, the use of PV panels helps to decrease the average total daily energy consumption by 910 kWh in a building with 1,000m^2 of available roof area for installing PV cells.

Wind power

- Use wind turbines to generate power. The applicability largely depends on local wind conditions (the height of installation is a major factor) and the possibility to construct an ingoing concentrated airstream into the turbine or turbine array.

  Turbine technologies are improving but installation costs are high. In the early stages the following calculation can be completed to check viability:

  P_{total} (Watts) = Mass-flow rate (Kg/s) x $KE_{incoming}$ = $0.5\ (\rho A V i^3)/g_c$

  P = Incoming wind density; Kg/m^3

  V = Incoming wind velocity; m/s

  A = cross-sectional area of stream; m^2

  g_c = 1 Kg x m / (N x s^2)

  The total power of a wind stream is directly proportional with its density, area, and its velocity to the third power.

  The total power specified above cannot be converted to mechanical power completely and therefore, the maximum available power of a wind turbine can be shown as the following:

  A wind turbine is only capable of converting 60% of the total power of wind to useful power at best:

$P_{max} = 0.3\ (\rho A V i^3)/g_c$

$\eta_{max} = P_{max}\ /\ P_{total} = 0.3\ (\rho A V i^3)/g_c\ /\ 0.5\ (\rho A V i^3)/g_c = 0.6$

The above equation assumes ideal conditions along the entire wind turbine blades. Usually because of spillage and other effects, practical turbines achieve only 50-70% of the ideal efficiency. Therefore, the real efficiency η and Actual Power of a wind turbine are related to the total power via the following formula:

$P_{actual} = \eta_{real} \times P_{total} = 0.5\ \eta_{real}\ (\rho A V i^3)/g_c$

Where η_{real} is about 30-40% for the current turbines on the market.

Assume a 15 m/s wind in condition of (1 atmosphere pressure and 15ºC) and a 10 m turbine diameter with ~40% real efficiency (η_{real}), the total actual produced power (P_{actual}) will be:

ρ (Air density) = P / RT =1.22 kg / m^3

$P_{total}\ /\ A = 0.5\ (\rho V i^3)/g_c = 0.5 \times (1.22 \times 153)/1 = 2060\ W/m^2$

$P_{actual}\ /\ A = \eta_{real} \times P_{total}\ /\ A = 0.4 \times 2060 = 824\ W/m^3$

$P_{actual} = 824 \times (3.14 \times 102/4) = 64680\ W = 64\ KW$

- Conduct more thorough studies into the local situation to verify whether the use of wind turbines is a viable possibility for the specific country. The prospect of using local, building-attached or building- integrated turbines is at face value illogical because the same investment as part of a wind park elsewhere, such as in an optimal dedicated location, would produce a far larger amount of electricity for the same investment.

Ground source heat pumps

- Consider using ground source heat pumps since the unlimited capacity of the ground as a sink and source of heat rejection can provide energy efficient cooling. Figures 18 and 19 show cooling and heating cycles.

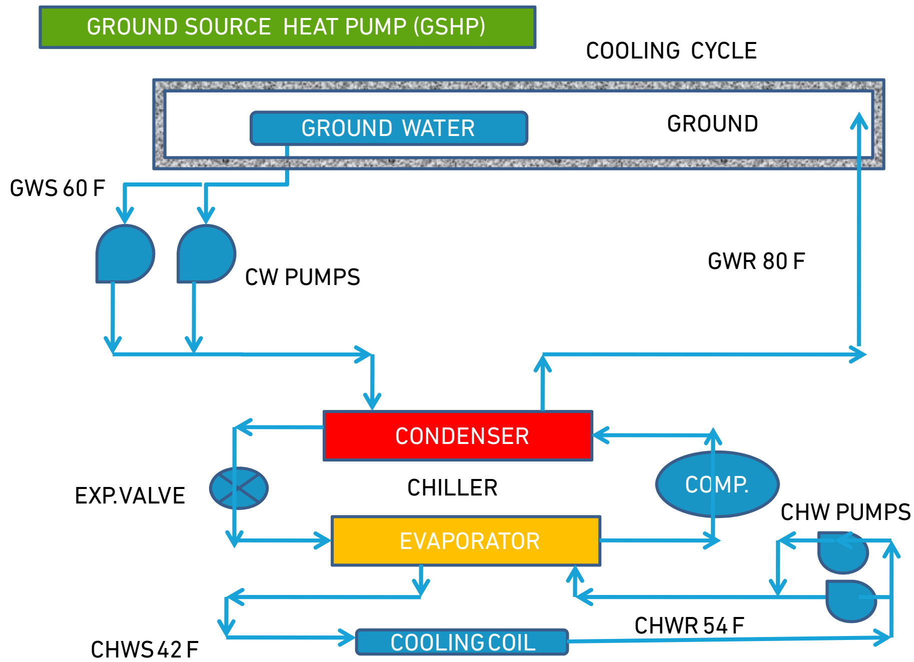

Figure 18 Ground Source Heat Pump for Cooling Cycle

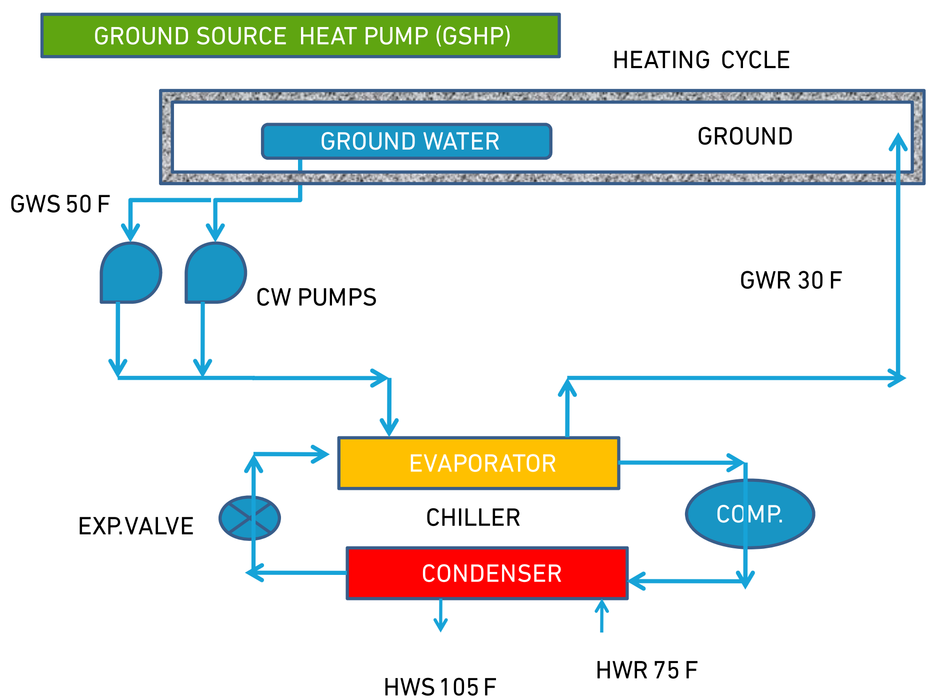

Figure 19 Ground Source Heat Pump for Heating Cycle

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4.0 WATER

The Water category is concerned with water conservation for indoor and outdoor use. The natural water cycle is a system in which water resources are continuously exchanged between the atmosphere, soil water, surface water, ground water, and plants. This cycle treats and recharges freshwater supplies. Human consumption of fresh water outpaces the natural cycle and under these circumstances, water cannot be considered as a renewable resource.

Sustainable practices for the efficient use of water, the collection, recycling and reuse of water to mitigate environmental impacts associated with water scarcity and depletion.

CRITERIA IN THIS CATEGORY:

W.1 Water Demand Performance

W.2 Water Reuse Performance

W.3 Water Sub-Metering

4.1 [W.1] WATER DEMAND PERFORMANCE

4.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

4.1.2 PURPOSE

To reduce the indoor and outdoor water demand of the development.

4.1.3 CONTEXT

A reduction in overall water demand and consumption can be achieved by adopting water conservation strategies for indoor and outdoor uses within the development. For indoor water use, the most effective approach is through the specification of efficient sanitary fixtures, for example: dual flush toilets and low flow fixtures incorporating aerators and timers. In addition, the specification of water efficient appliances can further reduce water demand and consumption.

To reduce outdoor water demand and consumption, effective landscape management practices can be employed. Landscape design can be developed and implemented to include the use of native vegetation or species with a low water demand. In addition, the use of efficient irrigation methods, including automated techniques and systems, with managed cycles, timing and overall control should be specified.

4.1.4 GUIDELINES

Water efficient equipment and fixtures

- Specify water efficient fixtures, for example, low flush toilets, vacuum toilet flush systems, dual flush toilets, flow-controllers, water-saving valves and fixtures on faucets and showerheads and low flush urinals.
- Specify water efficient equipment and appliances including dishwashers, washing machines or similar.
- Specify automatic shut-off's, electronic sensors, and aerators on faucets.
- Consider the use of dry fixtures for example: composting toilets and waterless urinals to reduce water demand.
- Install leak detection systems to quickly and efficiently identify and locate water leakage points.

Water efficient irrigation

- Design landscape for water efficiency by specifying native plants that are more tolerant to local soil and rainfall conditions.
- Shade the site where possible to minimize water loss due to evaporation.
- Minimize the use of potable water for irrigation using harvested/recycled rainwater and greywater where feasible.
- Group plants with similar water needs for the most efficient use of water and develop and implement appropriate watering schedules.
- Consider efficient, low-water irrigation systems for example: drip feed subsurface systems and utilize weather-based irrigation strategies such as rain shut-offs, moisture sensors, and evapotranspiration/smart irrigation controllers.
- Consider the use of irrigation techniques for greywater including drip feed subsurface systems, traditional evapotranspiration systems and shallow trench systems that allow for subsurface irrigation of plant roots.
- Merge, if feasible, the greywater reuse system with the irrigation system to reduce the need to treat greywater on-site and to reduce the need for potable water for irrigation use.
- Specify a subsurface irrigation system when using greywater to avoid possible risks to human health. Avoid the activation of irrigation systems during the day and utilize mulch and/or gravel to prevent water evaporation from the soil.

HOSPITALITY Scheme

- Introduce a linen reuse program to reduce overall water consumption. The program will encourage hotel guests to reuse towels, sheets, pillow cases, restaurant linens and other linens. Increasing the lifespan of linens, in addition to reducing water and chemical detergent consumption, can provide significant environmental and economic benefits for the hotel. Ensure that guests are aware of linen reuse through signage or published information in guestrooms. Allowing guests to choose to conserve water by reusing towels and not having sheets changed daily can contribute to a positive experience in the hotel stay and reduce water consumption.
- Recreational spaces might consist of areas that cannot reduce water consumption without affecting the requirements of the recreational activity. Examples of such venues include, but are not limited to, indoor pools, ice rinks or golf courses. Install sub-meters to monitor water usage for all pool and spa facilities. Limit pool and spa drainage by maintaining the chemical balance of pool water. Install chemical regulators to avoid human error when balancing chemicals. Pools may only require annual drainage, whereas spas require more frequent drainage, which can be further reduced through proper monitoring of the chemical composition. If applicable, install flow regulators within pools, hot tubs, or steam rooms to reduce water consumption from those devices. Post signage surrounding the pool deck and hot tub rooms requesting users to limit their pool and spa facilities to a designated time. Due to the intense energy required for desalination, consider using salt water pools. Saltwater pools reduce the need to purchase, store, add and handle chlorine by converting the salt to chlorine through a chlorinator device. As salt can be corrosive over time to metals like stainless steel or unsealed stone and cement, pool areas should be properly maintained and constructed of corrosion resistant materials. In addition, avoid landscaping in splash back areas around salt water pools as the saline may damage plants.
- Landscaped areas used for recreational activities and competition, should adopt landscape management practices that conserve water and course design should reflect water conservation policies such as limiting lawn areas and eliminating water hazards. For irrigation, use non-potable water sources such as harvested water or greywater recycled from hotel and/or facilities use. Further reduce the need for irrigation by installing water retention systems underneath the soil and cover putting greens with tarps during evening hours to trap condensation.

[W.2] WATER REUSE PERFORMANCE

4.1.5 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

4.1.6 PURPOSE

To maximize water recycling and reuse in the development.

4.1.7 CONTEXT

Reuse of water from on—site sources can further reduce the demand for fresh water. An onsite alternative water source is water sourced, collected, treated, stored, and utilized as recycled water.

Sources for reclaimed water include: rainwater, condensate water, greywater and community treated sewage effluent (TSE). Recycled and treated water can be reused indoors, in a restricted manner, or outdoor applications. Indoors, recycled treated water can be used where no contact with human beings is envisaged, for example: greywater for toilet flushing. There are a wider range of applications in outdoor use including: landscape irrigation, make-up water for cooling towers, washing and general cleaning purposes.

The quality of reused water from on-site sources is of prime importance. Where there is a possibility of human exposure to the recycled water additional treatment is necessary and it is critical to ensure the quality of the recycled water is appropriate according to local regulations.

4.1.8 GUIDELINES

Rainwater and condensate reuse

- Design the development to collect, store, and redistribute rainwater and condensate on the development site to reduce potable water consumption. The treatment of rainwater and condensate is dependent upon the quality of the water; they do not necessarily have to be treated prior to redistribution.
- Collect water generated by the operation of air conditioners, dehumidifiers and refrigeration units. Condensation does not necessitate a stringent treatment process but can contain contaminants, residual chemicals and bacteria.
- Harvest and collect rainwater using devices such as cisterns or underground tanks. Rainwater collected from roofs and other impervious surfaces on the site can be filtered using various methods, including screens and paper filters. Water collected from paved surfaces such as roads and parking lots may require oil separators and further treatment to eliminate oils, fuels and other harmful substances.

- Reuse on-site condensate and rainwater for non-potable applications including toilet/urinal flushing, landscape irrigation, custodial/janitorial uses, fire protection, cooling towers make-up water and car washing.

Greywater reuse

- Design the development to collect, store, and redistribute greywater in the development to reduce potable water consumption.
- Ensure proper treatment of greywater collected in the development. Greywater includes water discharge from building operations for example: laundry, bathroom sinks, water discharged from cooling towers and water fountains.
- Ensure greywater generated from kitchen and catering facilities is stored and treated separately from other sources as oils and fats are difficult to remove. Dual plumbing lines can be used to separate greywater from sewage water and should be installed during the initial construction.
- Reuse on-site greywater for non-potable applications including toilet/urinal flushing, landscape irrigation, custodial/janitorial uses, fire protection, cooling tower make-up water and car washing.

Treated Sewage Effluent (TSE) reuse

- Use, where applicable the communal TSE for outdoor applications in the development.
- Treat, if possible, sewage on-site to produce water that can be used for non-potable uses, depending on the type of treatment. Sludge may be taken to appropriate disposal facilities or biologically digested on-site to produce methane. Use separate plumbing lines for sewage to isolate water from other wastewater systems.

Water features

- Limit water features in and around the building or development to conserve water and use recycled water for recirculation.
- Design water features with trickling or cascading fountains as they lose less water to evaporation than those spraying water into the air.
- Avoid placing water features outdoors due to the loss of water from evaporation. Indoor and outdoor water features should be operated on separate systems to prevent additional water loss.
- Consider using salt water in water features to reduce the need for desalinated water and ensuring the water feature materials such as tile and stone can withstand the corrosive properties of salt.

4.2 [W.3] WATER SUB-METERING

4.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

4.2.2 PURPOSE

To install sub-meters for monitoring the major water consuming systems.

4.2.3 CONTEXT

The use of water submetering in buildings generates awareness of water conservation among users including landlords and tenants as they will be aware of the exact consumption profile and costs associated with their behavior.

Water sub-metering will also facilitate the development of strategies to help improve performance, thereby ensuring the overall efficiency of systems operations. In addition, Users can apply consumption data to implement conservation or renovation projects to lower usage & costs and meet government regulations.

Sub-metering devices are installed to monitor and evaluate energy performance and consumption during the building operations phase. Major water systems should be metered and monitored in conjunction with data logging to enable continued accountability of energy consumption over the lifespan of the development. Consumption data provides users with the information to locate leaks and high-consumption areas.

4.2.4 GUIDELINES

- Install water meters on the main water supply to each building in the proposed development.
- Provide water sub-meters for all major water-consuming systems, such as bathroom fixtures, hot water heaters, boilers, cooling towers, chilled water systems, competition-related equipment, and largescale food service equipment.
- Ensure that water meters are clearly labelled, easily accessible and convenient for facilities operators.
- Provide means for monitoring irrigation systems to control over-watering and to detect the build-up of nutrients for example: nitrogen, calcium, potassium, and sodium.
- Consider connecting the water meter to the building monitoring system using a pulsed output to ensure detection of inefficiencies in water use and consumption.
- Provide monitoring devices that display and record the water consumption data of major systems in the building.

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5.0 MATERIALS

The Materials category is concerned with the conservation of natural resources and the use or reuse of materials and structure to have the least environmental impact. The construction sector has a significant impact on the environment. It accounts for the consumption of approximately 40% of the raw stone, gravel, and sand used worldwide annually, 25% of the raw timber and the associated embodied carbon emissions for such materials.

Eco-friendly construction materials can contribute to reduce the adverse impacts on the environment, and create sustainable buildings promoting the health and well-being of occupants.

CRITERIA IN THIS CATEGORY:

M.1 Locally Sourced Materials

M.2 Materials Eco-Labeling

M.3 Recycled Content of Materials

M.4 Materials Reuse

M.5 Existing Structure Reuse

M.6 Design for Disassembly

M.7 Responsible Sourcing of Materials

5.1 [M.1] LOCALLY SOURCED MATERIALS

5.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

5.1.2 PURPOSE

To maximize the use of local material and reduce the impact of long-distance transportation.

5.1.3 CONTEXT

The concept of a local circular economy in the built environment creates a more sustainable, efficient, and resilient economic growth. Procuring goods and services originating from the local market helps fuel economic growth and provides opportunities for employment. The construction industry contributes significantly to the national economy as it encompasses the utilization of versatile supply chain elements including material procurement, workmanship provision, manpower supply and the use of resources.

For materials to be considered as locally sourced, loose materials and assembled finished products must be available and procured from within the country borders.

5.1.4 GUIDELINES

- Procure locally sourced materials to reduce the transportation distance which will mitigate the environmental impacts of transportation.
- Investigate the availability of locally produced products and develop a materials logistic plan to identify manufacturers in the local market.
- Develop a procurement program to ensure the availability of materials according to the development timeline. These considerations should take place early in the design process to assess which locally sourced materials will be most appropriate and feasible in terms of the development design and budget.
- Source locally, where available, primary building elements such as aggregate, concrete, masonry, sand, and steel since heavier materials require more energy to transport, hence they have a greater impact on the environment if sourced from outside the country.
- Consult the tools and guidance section provided by the Waste and Resources Action Programme (WRAP) in the United Kingdom for more information on materials logistics planning.

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5.2 [M.2] MATERIALS ECO-LABELING

5.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

5.2.2 PURPOSE

To use certified products and materials with enhanced environmental, health and resources conservation attributes.

5.2.3 CONTEXT

Environmental labels or eco-labeling has emerged as a useful tool for the society and offers a valuable contribution to the development and implementation of sustainable procurement practices. There are several objectives for pursuing eco-labeling including the following:

- Protecting the environment.
- Encouraging environmentally considered innovation and leadership.
- Developing consumer awareness of environmental issues.
- Linking eco-labelled materials with life cycle environmental assessment and embodied energy.

There are three main types of widely adopted eco-labeling programs, guided by internationally recognized standards and each is serving a different purpose and addresses different attributes:

- **Single-Attribute Labels**

  A single-attribute label identifies an individual environmental attribute associated with the product. An example of a single attribute label is the representation of recycled content or the energy efficiency performance of the product.

- **Multi-Attribute Labels**

  In contrast to single attribute labels, multi-attribute labels/standards represent collective characteristics of the product with an aim to set criteria for the range of environmental impacts that the product category should tend to minimize or avoid. This is typically done by focusing on life cycle environmental impacts of the product categories e.g. energy saving, carbon foot print reduction, recycle or reuse of material and impact on the ecosystem and public health. These labels are good indicators of the “greenness” of the product category and are awarded when all the criteria of the standard are met by the product category.

- **Environmental Product Declarations**

  Environmental Product Declaration (EPD) labels are awarded to a product for declaring its environmental impacts over its life cycle. The award of the label requires a thorough life cycle assessment study, which helps the comparison of the product with other products in the same category in terms of their life cycle environmental foot prints. EPD label helps users to compare the relevant data among products and make an informed decision.

5.2.4 GUIDELINES

- Procure eco-labelled materials and products which have enhanced environmental attributes.
- Investigate the availability of eco-labelled materials and products and develop a materials logistic plan to identify suppliers and manufacturers.
- Develop a procurement program to ensure the availability of eco-labelled materials and products according to the development timeline. These considerations should take place early in the design process to assess which eco-labelled materials and products will be most appropriate and feasible in terms of the development design and budget.
- Ensure the appropriateness and validity of material and product information and certification.
- Develop a matrix to identify the potential environmental impacts of materials and products to inform the decision-making process and specify alternative eco-labelled materials and products wherever possible.

FURTHER RESOURCES

Publications:

1. *A Guide to Environmental Labels -for Procurement Practitioners of the United Nations System*. UNOPS, 2009.
2. *Environmental Procurement Practice Guide*. Vol. 1, UNDP, 2008.
3. *Guidelines on Greening Public Procurement by Using the European Eco-Label Criteria*. EU Eco-label Helpdesk, 2001.
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5.3 [M.3] RECYCLED CONTENT OF MATERIALS

5.3.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

5.3.2 PURPOSE

To use products and materials with recycled content.

5.3.3 CONTEXT

The use of materials with recycled content reduces the environmental impact of extracting and processing non-renewable and virgin materials. Materials, products, components, fixtures and fittings made with recycled content can contain post- or pre-consumer content. Post-consumer content is waste that is recycled after the product has been used by a consumer. It may include construction or demolition debris such as recycled aggregate, steel and aluminum building elements, materials sorted for recycling purposes such as aluminum cans and glass bottles, and landscaping waste such as branches and leaves. Pre-consumer waste is raw material that has never been used by a consumer such as wood chips and sawdust. Pre-consumer materials are often by-products of manufacturing processes that can be recycled and reused.

5.3.4 GUIDELINES

- Procure materials and products with recycled content to reduce the need for the use of virgin materials.
- Investigate the availability of materials and products with recycled content and develop a materials logistic plan to identify suppliers and manufacturers.
- Develop a procurement program to ensure the availability of materials and products with recycled content according to the development timeline. These considerations should take place early in the design process to assess which materials and products with recycled content will be most appropriate and feasible in terms of the development design and budget.
- Ensure the appropriateness and validity of material and product information and certification where applicable.
- Develop a matrix to identify the potential environmental impacts of materials and products to inform the decision-making process and specify alternative materials and products with recycled content wherever possible.
- Ensure that the materials and products with recycled content selected for the development are of a high quality, have no detrimental environmental impacts, and will not hinder construction in any way.
- Use insulation, acoustic wall panels, and ceiling tiles made from materials with recycled content as they are widely available.

FURTHER RESOURCES

Publications:

1. Anderson, Jane, et al. *The Green Guide to Specification*. Blackwell Science Ltd, 2002.
2. *Construction Site Best Management Practice (BMP) Field Manual and Troubleshooting Guide*. Department of Transportation, State of California, 2013.
3. Coventry, S., et al. *The Reclaimed and Recycled Construction Materials Handbook: C513*. Construction Industry Research and Information Association, 1999.
4. *Field Guide for Sustainable Construction*. The Partnership for Achieving Construction Excellence, The Pennsylvania State University, 2004.
5. *Pollution Prevention by Building Green*. Office of Pollution Prevention, Ohio EPA, No. 86 2001.

5.4 [M.4] MATERIALS REUSE

5.4.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

5.4.2 PURPOSE

To reuse building materials recovered from on or off-site sources.

5.4.3 CONTEXT

The reuse of salvaged or refurbished materials and products recovered on- or off-site prevents diversion of such materials into the waste stream and reduces the environmental impacts associated with producing new materials and products. Salvaged materials are those materials taken from existing buildings and reused in new buildings and developments. Salvaged materials include steel structural elements, flooring, paneling, windows, doors and frames, cabinetry, and masonry. They can be purchased from suppliers or recovered and relocated directly from an existing building.

5.4.4 GUIDELINES

- Identify salvaged materials and products for reuse to reduce the need for the procurement of virgin materials and develop a materials logistic plan to identify suppliers and manufacturers.
- Develop a procurement program to ensure the availability of salvaged materials and products for reuse according to the development timeline. These considerations should take place early in the design process to assess which salvaged materials and products for reuse will be most appropriate and feasible in terms of the development design and budget.
- Ensure the appropriateness and validity of salvaged material and product information where possible.
- Develop a matrix to identify the potential environmental impacts of materials and products to inform the decision-making process and specify alternative salvaged materials and products for reuse wherever possible.
- Ensure that the salvaged materials and products for reuse selected for the development are of a high quality, have no detrimental environmental impacts, and will not hinder construction in any way.

FURTHER RESOURCES

Publications:

1. Anderson, Jane, et al. *The Green Guide to Specification*. Blackwell Science Ltd, 2002.
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9. *Sustainable Construction: Simple Ways to Make It Happen*. bre, 2008.

5.5 [M.5] EXISTING STRUCTURE REUSE

5.5.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

5.5.2 PURPOSE

To reuse or renovate existing on-site structural systems.

5.5.3 CONTEXT

The reuse of existing on-site structure systems in the development reduces the impacts associated with the extraction and processing of virgin and non-renewable resources as well as the impacts of waste diversion to landfill.

In addition, the reuse of existing structural systems is evident in buildings of significant historical and architectural interest for conservation and buildings of less significance which nonetheless contribute to the character and urban grain of an area or neighborhood. Existing buildings offer real opportunity and potential for redevelopment and alteration leading to subsequent repurpose and reuse.

In situations where there are existing structural systems on-site, a thorough investigation of the suitability and condition of the structure must be undertaken. Structural systems to be reused include the foundation and slab, basement and retaining walls, exterior walls, floors, roof structure and interior loadbearing walls. Reuse of the existing structural systems should not necessitate significant strengthening or alteration to make them structurally viable.

5.5.4 GUIDELINES

- Determine whether the existing structural systems are in good condition, fit for purpose and remove any element that may be harmful to the proposed development.
- Document and record all the existing structural systems to be reused.
- Conduct an environmental and techno-economic feasibility study on the reuse of existing structural systems compared with the demolition and construction of new structure.
- Ensure that the reuse of existing structure does not necessitate significant strengthening or alteration to make it structurally viable.
- Ensure that the reuse of existing structure does not have any potential for health and safety impacts on the proposed development, future occupants and users.

FURTHER RESOURCES

Publications:

1. Orbasli, Aylin. "Re-Using Existing Buildings towards Sustainable Regeneration." *School of Architecture: Place and Culture Identity Group Working Paper*, 2009.
2. The Recyclable Housing Technology Development Project, editor. *Sustainable Housing*. Toyo Keizai Inc, 2003.
3. Tsubakihara, Y., and K. Yamashita. "Reuse of Existing Piles in Building Reconstruction and Its Environmental Effects." *Proceedings of the 2005 World Sustainable Building Conference*, 2005.

5.6 [M.6] DESIGN FOR DISASSEMBLY

5.6.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

5.6.2 PURPOSE

To design building elements for ease of disassembly and facilitate future reuse.

5.6.3 CONTEXT

Design for disassembly is a practice to benefit and simplify the deconstruction processes and procedures through forward planning and design. It also changes the traditional waste management process and conserves raw materials. Design the building to facilitate future disassembly of components for reuse to extend the life of materials and conserve natural resources. Building elements and components—including structure, finishing materials, and equipment—should have the ability to be easily separated and disassembled. Elements that qualify for consideration for disassembly exclude consumables, elements indicating significant signs of wear and tear and electro-mechanical components and systems.

5.6.4 GUIDELINES

- Consider the use of modular components, movable partitions, and bolted connections or fastening systems for the structure and/or building envelope to facilitate future disassembly.
- Minimize, where feasible, the use of composite or bonded materials that cannot be separated or reused.
- Design internal finishes and fixtures to be easily removable to enable refurbishment and remodeling.
- Specify, where feasible, the design of standard components and assemblies to enable faster and simpler future disassembly and reuse.
- Adopt innovative strategies for the integration and connection of building elements and components where feasible to enable easy and fast future disassembly.
- Develop and submit a manual and all necessary documentation outlining the disassembly instructions for various systems and components in the development to ensure that transfer of knowledge is retained for future use.

FURTHER RESOURCES

Publications:

1. Crowther, Philip. *Design for Disassembly to Extend Service Life and Increase Sustainability*. Edited by Michael A. Lacasse and Dana J. Vanier, Durability of Building Materials and Components 8: Service Life and Asset Management conference, 1999, pp. 1983–92, https://eprints.qut.edu.au/2471/.
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5.7 [M.7] RESPONSIBLE SOURCING OF MATERIALS

5.7.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

5.7.2 PURPOSE

To use certified responsibly sourced materials.

5.7.3 CONTEXT

Responsible sourcing is a commitment by society to go beyond economic considerations and to account for social, ethical and environmental considerations when managing relationships with the supply chain of construction materials.

The growing practice of specifying and procuring responsibly sourced materials is promoting the conservation of natural resources, reducing the environmental impacts associated with the extraction and processing of non-renewable materials in addition to improving social and labor conditions.

In the case of timber, responsible sourcing helps mitigate the over-harvesting of forests that has led to the extinction of many tree species and the depletion of wood as a natural resource.

5.7.4 GUIDELINES

- Procure responsibly sourced materials and products which have enhanced environmental attributes.
- Investigate the availability of responsibly sourced materials and products and develop a materials logistic plan to identify suppliers and manufacturers.
- Develop a procurement program to ensure the availability of responsibly sourced materials and products according to the development timeline. These considerations should take place early in the design process to assess which responsibly sourced materials and products will be most appropriate and feasible in terms of the development design and budget.
- Ensure the appropriateness and validity of material and product information and certification.
- Develop a matrix to identify the potential environmental impacts of materials and products to inform the decision-making process and specify alternative responsibly sourced materials and products wherever possible.

Timber Products

- Use timber and wood products originated from sustainably managed forests.
- Use timber supplied by companies that hold Forest Stewardship Council (FSC) Chain of Custody Certification.
- Use products originated from forest management companies that comply with local regulations, demonstrate long–term land tenure and use rights, recognize the rights of indigenous people, maintain the ecology and biodiversity of the forest, enhance economic viability, and conduct adequate management, planning and monitoring of operations.

FURTHER RESOURCES

Websites:

1. "Convention on International Trade in Endangered Species of Wild Flora and Fauna." *Cities.Org*, https://www.cites.org/eng/disc/what.php. Accessed 4 Sept. 2019.
2. "ILO Declaration on Fundamental Principles and Rights at Work and Its Follow-Up." *International Labour Organization (ILO)*, http://www.ilo.org/declaration/thedeclaration/lang--en/index.htm. Accessed 4 Sept. 2019.
3. "The Global Conservation Organization." *World Wildlife Federation (WWF)*, http://wwf.panda.org/. Accessed 4 Sept. 2019.
4. "Universal Declaration of Human Rights." *United Nations (UN)*, 6 Oct. 2015, https://www.un.org/en/universal-declaration-human-rights/index.html.

Publications:

1. Anderson, Jane, et al. *The Green Guide to Specification*. Blackwell Science Ltd, 2002.
2. *Environmental Impact of Building and Construction Materials*. CIRIA, 1995.
3. *ICC Guide to Responsible Sourcing*. International Chamber of Commerce, 2008.
4. International Labour Office. *Tripartite Declaration of Principles Concerning Multinational Enterprises and Social Policy*. 5th ed., International Labour Organization, 2017.
5. *ISO 9001:2008 Quality Management Systems - Requirement*. International Organization for Standardization, 2008.
6. *ISO 14001:2004 Environmental Management Systems - Requirements with Guidance for Use*. International Organization for Standardization, 2004.
7. *ISO 26000:2010 Guidance on Social Responsibility*. International Organization for Standardization, 2010.
8. *Sourcing Reclaimed Material for Use in FSC Product Groups or FSC Certified Projects*. Forest Stewardship Council, 2011.

6.0 INDOOR ENVIRONMENT

The Indoor Environment category is concerned with the quality of the indoor environment for the comfort, health and well-being of occupants and users. People spend most of their time indoors and the quality of the indoor environment has a direct impact on their health, comfort, well-being and satisfaction. The building design should promote a comfortable, healthy and safe environment for building occupants and users.

CRITERIA IN THIS CATEGORY:

IE.1 Thermal Comfort

IE.2 Natural Ventilation

IE.3 Mechanical Ventilation

IE.4 Lighting

IE.5 Daylight

IE.6 Glare

IE.7 Views

IE.8 Acoustics

IE.9 Low-VOC Materials

IE.10 Airborne Contaminants

6.1 [IE.1] THERMAL COMFORT

6.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.1.2 PURPOSE

To optimize conditions for a thermally comfortable environment.

6.1.3 CONTEXT

Thermal comfort can be defined as "that condition of mind which expresses satisfaction with the thermal environment" (CEN, 2005).

Accumulated research studies on the relationship between temperature and workers performance indicate that there is a negative impact on performance due to a warmer temperature of 30°C and a cooler temperature of 15°C, as compared to that at a human comfort temperature range of 21°C to 23°C. Similarly, work-related fatigue is higher at higher relative humidity (e.g. 70% RH) as compared to lower relative humidity (30-40% RH). It is acknowledged that work spaces need to be thermally comfortable for occupants to remain productive to their full capacity. Thermal comfort is based on the thermal adaptation of the individual occupant which is correlated to factors including geographic location and climate, time of year, gender, race, and age.

Thermal comfort of building occupants is dependent upon both environmental conditions and personal factors.

Environmental conditions include:

- Ambient temperature (air temperature)
- Radiant temperature (the temperature of the surfaces around the occupants such as walls, ceiling, floor and windows)
- Relative humidity (indicative of the amount of water vapor in the air -vapor mixture)
- Air velocity (the rate at which air moves around and touches the skin)

Personal factors include:

- Metabolic rate (The activity of a person in terms of amount of energy expended)
- Clothing insulation (The type of clothing a person wears to retain or dissipate body heat)

Thermal discomfort generally occurs when the surrounding thermal environment does not meet the requirements of the human mind or body. In warmer environments perspiration can start, possibly leading to hyperthermia in extreme cases. These responses are reactions to uncomfortable environments.

Provision of means to control parameters of thermal comfort is a key component. When occupants can adapt to the thermal environment by adjusting or changing clothing, varying the air speed across their bodies or adjusting blinds, then increasing variations in space temperature can be tolerated.

6.1.4 GUIDELINES

- Achieve thermal comfort using one of the following methods: active conditioning (mechanical HVAC systems), passive conditioning (natural ventilation), or a combination of both active and passive conditioning. A hybrid system may be more suitable and effective for developments in a hot, dry climate.
- Ensure that the development design includes an efficient and appropriate building envelope responsive to climate conditions to help achieve the desired thermal comfort levels.
- Use one of the available HVAC load calculation methods to facilitate the selection of appropriate equipment to reach optimal thermal conditions within the building.
- Ensure that the design of the HVAC system capacity for spaces can satisfy the peak cooling load so that the thermal comfort of occupants in a space can be guaranteed for the hottest hour of the year.
- Provide appropriate control devices to set the optimum thermal conditions to the extent that they do not compromise the energy performance of the building. Ensure the HVAC system is flexible and can respond to part-load demands to provide optimum thermal conditions to minimize energy use.
- Install automatic control systems for thermal comfort including those dynamic elements that have an influence on the thermal environment such as electric window openers and external shading devices.
- Design the HVAC system to be flexible and to respond to part-load demands to provide optimal thermal conditions while minimizing energy use.
- Conduct building simulations early in the design process to verify the zoning and control levels necessary to achieve the desired thermal comfort levels over the entire year and with variable occupancy/vacancy.
- Use the Predicted Mean Vote (PMV) or Air Diffusion Performance Index (ADPI) method for the assessment of thermal comfort in the design of the development.

Predicted Mean Vote (PMV) method

- The PMV method evaluates and relates the environmental conditions and personal factors by employing a thermal sensation scale to determine overall thermal comfort. The most important factors for achieving thermal comfort in buildings that are actively conditioned are air temperature and humidity, both of which can be controlled through the design of the air conditioning system. PMV calculations may use the assumed design values for other secondary factors such as air velocity.
- Consider the mean radiant temperature that can vary due to design decisions such as exterior construction materials and the presence of shading devices.

Air Diffusion Performance Index (ADPI) method

- The ADPI method evaluates the spatial conditions of air temperature and speed to convey a single-number means of relating temperatures and velocities in an occupied zone to the occupants' thermal comfort. Higher ADPI values are desirable as they represent a higher comfort level.
- Calculate the ADPI of a space to determine the worst case by measuring the temperature and air velocities at points throughout the occupied space. These points are defined by ASHRAE as being the area six feet high from the floor and one foot away from the walls. The temperature and velocity at each measured point are used to calculate an effective draft temperature—a draft temperature of 0 is considered thermally neutral. Negative draft temperatures equate to cooling sensations, while positive values represent a predicted feeling of warmth. For more information, consult the ADPI curves in Chapter 31 of the ASHRAE Handbook of Fundamentals.

EDUCATION Scheme

- Thermal comfort is essential for a learning environment. Rooms that are too hot or too cold can significantly decrease the attention span and performance of students and teachers.
- Provide each classroom with individual temperature control, allowing teachers to adjust the temperature as necessary.
- Avoid "hot spots" which are extremely bright areas that are created by direct sunlight.
- Use operable windows and user-controlled shades and blinds.

HOSPITALITY Scheme

- Provide guestrooms with individual smart thermostats to control the indoor temperature. Smaller hotels most commonly use stand-alone package terminal air conditioners (PTACs) for in-room temperature control. Larger hotels may be better served with a networked system of chillers and boilers that offer localized control. Because studies have shown that many sold guestrooms remain unoccupied for 12 or more hours per day, hotels should link automated systems, such as energy management systems (EMS), reservation systems, and automated check-out systems, so that unoccupied rooms will not use excess energy.

- Install automatic keycard systems which can greatly reduce power consumption in unoccupied rooms by shutting off most power-consuming devices like the HVAC unit when a guest leaves and automatically restarting the temperature control and lighting upon return to the room.
- Provide, where possible, operable windows in all guestrooms to enhance the range of thermal comfort options while further reducing energy consumption.

MOSQUES Scheme

- Design a flexible HVAC system as this is particularly important for prayer areas in mosques, since there is a high fluctuation of occupant density throughout the day.

LIGHT INDUSTRY Scheme

- In light industrial facilities, different consideration should be given to both office and operational areas. Operational areas can require specific heating and cooling requirements such as cold storage areas or painting workshops. When the temperature of certain spaces is above or below normal thresholds, workers should be provided with adequate clothing and protection to ensure their health and comfort.
- Ensure the ventilation system is designed to handle additional cooling loads in different operational areas which require different thermal comfort levels.
- Ensure the design of ventilation systems is capable to handle the cooling and heating loads of both operational and office areas. While office areas associated with light industrial facilities typically have the same requirements for thermal comfort, they are susceptible to heat gains associated with adjacent operational areas. When operational areas generate excessive heat, ventilation systems should be sized to handle the additional cooling loads.

FURTHER RESOURCES

Websites:

1. *Usable Buildings*. https://www.usablebuildings.co.uk/. Accessed 4 Sept. 2019.

Publications:

1. *ANSI/ASHRAE Standard 55-2004 Thermal Environmental Conditions for Human Occupancy*. American Society of Heating, Refrigeration, and Air Conditioning Engineers, 2004.
2. *ANSI/ASHRAE Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality*. American Society of Heating, Refrigeration, and Air Conditioning Engineers, 2004.
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4. Bauman, Fred S. "Giving Occupants What They Want: Guidelines for Implementing Personal Environmental Control in Your Building." *Berkeley: Center for the Built Environment, University of California*, 1999, https://escholarship.org/uc/item/55c7r2hz.
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8. "Chapter 12: Hotels and Motels." *ENERGY STAR Building Upgrade Manual*, U.S. Environmental Protection Agency, 2007.
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10. Harriman, Lew, et al. *Humidity Control Design Guide for Commercial And Institutional Buildings*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2001.
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6.2 [IE.2] NATURAL VENTILATION

6.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.2.2 PURPOSE

To maximize fresh air supplied naturally when conditions permit without the aid of mechanical systems.

6.2.3 CONTEXT

The design of developments to effectively utilize natural ventilation strategies within mechanically ventilated buildings can minimize energy use and provide fresh outdoor air to building occupants. Natural ventilation strategies should provide for an adequate flow of air within occupied spaces to ensure appropriate thermal comfort conditions. In buildings employing a naturally ventilated system, it is recommended that the total area of operable windows is at least 5% of the total floor area of the room to provide for effective ventilation. In addition, more than 90% of all occupied spaces should be designed for cross-ventilation.

The design of the acclimatization systems of a building can be flexible to facilitate conversion between mechanical and unassisted natural ventilation strategies as required. During cooler months, the building may be able to utilize natural ventilation strategies, thereby conserving energy. Additionally, allowing for natural ventilation within a mechanically ventilated building enables fresh air to be introduced into the building, alleviating odors and improving occupant comfort.

The natural features of the site including the direction of prevailing winds and density of surrounding buildings can affect the ability to provide natural ventilation. Buildings can be orientated to take advantage of naturally occurring ventilation patterns throughout the site.

6.2.4 GUIDELINES

- Analyze the number of months that natural ventilation can be utilized based on the hourly climatic conditions of the site.
- Identify the spaces that are predominantly occupied and suitable for the implementation of strategies to provide natural ventilation.
- Use calculations to determine effective ventilation within the building, using ventilation design tools recommended by CIBSE AM 10:2005 or equivalent. An analytical model may also be used to predict whether room- by-room airflows will provide adequate ventilation.

- Provide operable windows and/or trickle vents on windows to allow for the possibility for natural ventilation in the proposed building.
- Use cross-ventilation to promote air flow within the building by placing operable windows on at least two separate walls in one space, preferably on two opposing walls for the most effective air circulation.
- Ensure that the number, location, operation and type of windows allow for sufficient levels of fresh air and ventilation.
- Design to permit users and occupants to open windows at will to allow for individual comfort and well-being.
- Ensure that all opening mechanisms of all operable windows are conveniently located and accessible for ease of use.
- Locate operable windows away from any sources of pollution to avoid indoor air contamination.
- Optimize opening sizes and airflow in building with complex geometries.
- Consider the use of ventilated skylights which can provide an opening for stale air to escape in a flexible ventilation strategy. The lightwell of the skylight can also act as a solar chimney to assist the flow.

MOSQUES Scheme

- Many mosques have courtyards and porticos. These spaces are often shaded and can facilitate natural ventilation of the prayer hall. Allow hot air to escape from the prayer hall by placing windows high in the space. Cool air can then enter from the adjacent courtyards or porticos and create effective air circulation.

FURTHER RESOURCES

Websites:

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Publications:

1. *ANSI/ASHRAE Standard 62.1-2004 Ventilation for Acceptable Indoor Air Quality*. American Society of Heating, Refrigeration, and Air Conditioning Engineers, 2004.
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6.3 [IE.3] MECHANICAL VENTILATION

6.3.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.3.2 PURPOSE

To maximize fresh air supplied with efficient mechanical ventilation systems.

6.3.3 CONTEXT

There are two indoor air quality requirements that the room or space must maintain for its occupants. The first requirement is the air in the breathing zone should conform to the local health standards tolerance for health risk. The second requirement is the supply air and recirculated air in the space as perceived by occupants must be fresh and pleasant rather than stale, stuffy and possibly irritating.

With prolonged exposure, there are indoor air pollutants that could pose certain health risks to human beings. The health risks associated may be comprised of distinct, acute, or long-term adverse effects.

It is important to have an efficient and properly functioning air-conditioning and mechanical ventilation systems in the building to maintain the desired indoor air quality control. The quality of the indoor air systems can greatly impact the occurrence of respiratory diseases, the symptoms of allergies and asthma, the transmission of infectious diseases, chemical sensitivity and occupant productivity. High-efficiency particulate air filters can significantly reduce the risk of airborne pollutants thus reducing infection rates caused by a wide range of airborne pathogens.

Higher indoor CO2 concentration levels due to an inadequate ventilation rate are associated with occupants experiencing a tendency to be less satisfied with the indoor air quality as occupants report more acute health symptoms for example headache or mucosal irritation. It is argued that higher levels of various indoor-generated pollutants that can directly cause such adverse effects are associated with higher indoor CO2 concentrations occurring at lower outdoor air ventilation rates.

Effective ventilation for buildings ensures that occupant well-being and comfort can be achieved. Ventilation rates and air quality levels should meet the minimum compliance requirements of the following: ASHRAE Standard 62.1: Ventilation for Acceptable Indoor Air Quality, the equivalent CIBSE, or other accepted standard.

6.3.4 GUIDELINES

- Design an effective ventilation system that promotes efficient air exchange. The design should ensure that the outdoor air delivered to interior spaces will be delivered adequately to building occupants.
- Position fresh air intakes away from exhaust vents to minimize recirculation.
- Locate outdoor air intakes away from pollution sources including building exhaust air louvers, exhaust outlets from adjacent buildings, cooling towers, loading docks, air exhaust from waste facilities, parking garages, transportation stops, smoke discharge openings and dedicated exhausts from toilets and kitchens.
- Protect outdoor air intake openings from rainwater, animals and debris with screens and bird guards, and specify ventilation lining that will not release contaminants into the air path.
- Utilize a high-efficiency air filtration system to remove particles from the outdoor air before being distributed throughout the building.
- Ensure that the final filter in the system has an expected efficiency of higher than 90%.
- Minimize the risk of contamination by encapsulating or removing exposed insulation inside ducts, air-handling units and variable-air-volume boxes.
- Consider using positive building pressurization in hot climates to prevent warm and humid air from seeping into the building.
- Provide building occupants and users with the ability to individually control ventilation rates to ensure thermal comfort and well-being.
- Ensure that the ventilation air paths of mechanical ventilation systems are easily accessible for maintenance and servicing.
- Consider the balance between fresh air supply and energy efficiency when specifying and designing the ventilation systems.
- Use carbon dioxide sensors in air-conditioned buildings to ensure appropriate ventilation in response to varying occupancy levels and uses.

MOSQUES Scheme

- Because occupant density will vary significantly depending on prayer times, HVAC systems should be flexible enough to adapt to various occupancy loads. For example, consider the need to accommodate many people for midday Friday prayers and during the holy month of Ramadan. Other prayer times should have lower occupancy rates and thereby, a lower demand on the ventilation systems.

FURTHER RESOURCES

Publications:

1. *ANSI/ASHRAE Standard 55-2004 Thermal Environmental Conditions for Human Occupancy*. American Society of Heating, Refrigeration, and Air Conditioning Engineers, 2004.
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4. *ASTM D6245-1998 Standard Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation*. American Society for Testing and Materials, 1998.
5. *Best Practice in the Specification of Offices - BCO Guide 2005*. British Council for Offices, 2005.
6. *Building Air Quality: A Guide for Building Owners and Facility Managers - EPA 402-F-91-102*. U.S. Environmental Protection Agency, 1991.
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6.4 [IE.4] LIGHTING

6.4.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.4.2 PURPOSE

To meet minimum compliance requirements for artificial illumination performance and avoid over-lighting of indoor spaces.

6.4.3 CONTEXT

Interior lighting and illumination is critical to the wellbeing and security of everybody using an indoor environment. Poor lighting can influence the health of people at work causing side effects like eye fatigue, headache and migraines. It is also connected to 'Sick Building Syndrome' in new and renovated buildings. Side effects of this include cerebral pains, laziness, crabbiness, poor focus and low productivity.

Aspects that would normally be considered for ensuring high quality of visual performance include levels of lighting; uniformity and ratios of illuminance; glare; color and room reflectance; energy efficiency; and other special considerations. The illuminance values recommended by established standards are valid for normal visual conditions and take into account the following factors: psycho-physiological aspects including visual; comfort and well-being; visual task requirements; visual ergonomics; practical experience; contribution to functional safety; and economic impact. The lighting should be maintained at higher levels when: visual work is critical; errors are costly to rectify; accuracy, higher productivity or increased concentration is of great importance; task details are of unusually small size or low contrast; the task is undertaken for an unusually long time; and the visual capacity of the occupant is below normal.

6.4.4 GUIDELINES

- Design the development lighting systems to ensure adequate illumination levels and light quality for the visual comfort and well-being of occupants.
- Reduce the energy required for electrical lighting by incorporating daylighting, considering that admitting daylight into a building interior may also increase solar heat gain and consequently cooling demand.
- Ensure, by calculation and simulation that the benefits obtained from daylighting will not be compromised by a significant increase in cooling system energy use. The quality and quantity of daylighting within a building is determined by fenestration design, glazing properties, room geometry, interior surface finishes and shadows cast from adjacent buildings.

- Control daylight admission to interior spaces using plants, blinds, shades, light-scattering glazing or external architectural shading devices including louvers and baffles.
- Consider the use of atria skylights and clerestories to allow light into interior spaces, especially at the core of the building.
- Provide light levels no less than those recommended in the IESNA Lighting Handbook, or equivalent.
- Determine the appropriate light levels for each of the different task-related spaces in the proposed building and design the lighting system to meet those requirements. For example, tasks that take place in a conference room are considered 'visual tasks of high contrast and large size,' and would require a horizontal illuminance value of 30 foot-candles according to the IESNA standard.
- Avoid over-illumination of entire rooms or spaces by providing individual task or accent lighting where higher illumination levels are required.
- Specify energy efficient lighting lamp technologies such as solid-state LED lamps or other energy saving fixtures.
- Ensure that lighting systems allow for adjustments by the occupants as necessary to promote comfort and maximize visual performance. Lighting controllability is the degree of control an individual has to turn lights off and on, adjust brightness and change the direction of light.
- Design lighting controls to the function of each space, number of occupants, usage pattern and the level of daylighting within each space.
- Coordinate light fixture layouts with furniture layouts to maximize lighting system efficacy.
- Consider the following important factors when specifying fixtures to improve light quality and visual comfort within the building: luminance ratio limits, veiling reflections, reflected glare, shadows, color and intensity.
- Minimize illumination intensity and lighting power through the specification and selection of energy-efficient lamps and fixtures.
- Use high frequency control gear fittings to minimize discomfort due to the flicker caused by luminaires that have a low frequency, for example, older fluorescent luminaries.
- Consider lighting design strategies including light shelves and indirect lighting systems that reflect light off the ceiling, providing uniform and ambient lighting conditions. The ceiling shape may be designed to more efficiently distribute light from windows or skylights using sloped or curved ceiling surfaces. The color, texture, and reflectance of interior finishes in a room can also help improve light conditions.

EDUCATION Scheme

- The variety of activities that take place in a classroom require a highly flexible lighting system that is user controlled. A recommended method for electric lighting is the use of suspended linear lights above a flat, white ceiling. This system works best in spaces that have a ceiling height of at least 2.75 meters. The electric lighting system should incorporate daylighting. One method for doing this is with daylight sensors, allowing electric lights to be automatically dimmed or switched off when there is a sufficient amount of daylight. Some lighting fixtures may be multi-scene enabled, which allows them to switch between direct and indirect lighting (downward or reflected off the ceiling). This is particularly useful in classrooms and spaces that use projectors and can require a darkened room.
- For classrooms where dry-erase boards are used often, consider providing lighting specifically for the board. Dry-erase boards have more contrast than chalkboards.
- Position electric lighting fixtures carefully to avoid glare. Avoid locating dry-erase boards on a wall that is opposite a daylighting source.
- For gymnasium lighting, industrial high bay LED and fluorescent luminaires are recommended. Alternatively use multiple compact fluorescent or LED luminaires in a single housing. Be sure to protect the lamps from flying balls.
- For library lighting, it is recommended that spaces used for reading have 20-50-foot candles. As for classrooms, suspended LED or fluorescent luminaires are a good specification for spaces with a ceiling height of at least 2.75 m. Task lighting should be used as well. Table lamps with LED or compact fluorescent lamps are an energy efficient option. Under-shelf task lights using LED or fluorescent lamps are an alternative option.

HOSPITALITY Scheme

- Maximize available daylight to reduce the artificial lighting needs in common spaces and guestrooms. For deep-plan hotels, consider designing atria with wells featuring proper geometric angles and reflective surfaces to bring daylight into the core of the building.
- Many zones in a hotel, such as public areas, back-of-house service areas, and office areas, may contain light sources that operate continuously over a 24-hour period. As a result, the energy consumption of lighting in a hotel can be significant.
- Hotel typologies may vary greatly and include a variety of differently programmed spaces including guestrooms, dining areas, recreational facilities, etc. Therefore, all spaces should provide light levels no less than those recommended in the IESNA Lighting Handbook, or equivalent. Furthermore, ASHRAE standards mandate that all hotel and motel guestrooms and suites must have a master control device at the main room entry that controls all permanently installed luminaries and switched receptacles. Master controls for lighting may also be integrated into the hotel's electronic key card system to guarantee automatic shut-off when guestrooms are unoccupied.
- Consider the use of automatic lighting control systems for spaces where both daylight and artificial lighting are used to minimize energy use (e.g. atria, indoor pools, retail areas, etc.). Automatic lighting control systems include the use of timers, daylight controls, and occupancy/vacancy controls.
- Use sensors within the lighting system to adjust illumination levels in response to variable daylighting conditions and user occupancy/vacancy.
- Provide dimmable and stepped daylighting controls for greater control over the building's electric lighting system.

FURTHER RESOURCES

Websites:

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Publications:

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3. Boed, Viktor. *Controls and Automation for Facilities Managers: Applications Engineering*. CRC Press, 1998.
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6.5 [IE.5] DAYLIGHT

6.5.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.5.2 PURPOSE

To maximize exposure to daylight and reduce the demand for artificial lighting.

6.5.3 CONTEXT

Based on research studies, daylight has been associated with reduced stress, improved performance and reduced errors, reduced absenteeism, increased positive attitude, reduced fatigue and improved job satisfaction. In addition, daylight provides contact with the outside living environment and improves circadian rhythms by affecting melatonin production and regulation. Also, windows provide a feeling of closeness to the surrounding environment and atmosphere.

The average daylight factor is influenced by building form, size and area of windows in relation to the room, the light transmittance of the glass, how bright internal surfaces and finishes are, the presence of overhangs and other external obstructions which may restrict the amount of daylight entering the room. Building geometry and interior space planning should promote, rather than preclude, the distribution of daylight. The size and proportion of windows should depend on the amount of daylight required, type of view, the size of the internal space, and the position and mobility of occupants. When windows are confined to one wall only, it is recommended that the total width of the windows range between 25-50% of the length of the wall to offer optimum viewing opportunity.

Top lighting is when daylight penetrates a building from above the ceiling plane or is concentrated in the roof. Common top lighting strategies include: skylights, courtyards, lightwells and atria. Sunlight should be admitted unless it is likely to cause thermal or visual discomfort to the users, or deterioration of materials. However, adequate measures should be taken for controlling glare while designing to maximize daylight in buildings.

Incorporating strategies for daylighting increases the comfort and well-being of occupants and users while reducing the energy consumed by artificial lighting. By integrating daylighting into the overall lighting approach of the building a balance can be created between natural and artificial lighting.

Daylight can be modulated in a variety of ways, making it an appropriate solution for the different spaces within a building. The following outlines a number of these daylighting techniques:

View Window: A view window is vertical glazing at eye level. While this can be a good source of daylight, there is a potential for glare and for “hot spots” created by direct sunlight. Louvers, blinds, and shades can help prevent these negative effects.

High Side-lighting/Clerestory with Light Shelves: As with view windows, this technique brings in daylight from the side. However, placing the window high on the wall helps to evenly distribute the light through the room. The use of a light shelf will also help with light distribution and can help minimize glare. High side- lighting works best in spaces with high ceilings.

Wall Wash/Top-lighting: This technique is achieved by placing a skylight next to a wall. The daylight is distributed over the surface of the wall, providing indirect light.

Central Top-lighting: Louvers or baffles should be used to avoid direct sunlight and to evenly distribute the light.

Patterned Top-lighting: This technique consists of multiple skylights spread out over a large area in a grid. It produces even, low glare illumination which is good for large areas including gymnasiums, libraries, and cafeterias. Spacing for the skylight grid should ideally be 1 to 1.5 times the floor to ceiling height.

Linear Top-lighting: This is a good technique for hallways. It produces a strong linear light that can aid with orientation.

Tubular Skylights: These skylights reflect daylight down through tubes. If they are used in a grid of proper dimensions, they can provide an even distribution of light. They are good for retrofits and useful in areas with deep roof cavities, since they can be designed to fit between the framing of a roof.

6.5.4 GUIDELINES

- Determine the lighting needs in the spaces throughout the development and take measures to maximize the daylighting potential of the building.
- Develop daylighting strategies considering the building orientation and the design of exterior and interior spaces.
- Orientate the development away from obstructing objects and other buildings to capture the maximum amount of light.
- Consider design elements, such as atria, courtyards, skylights, and shading devices, to harvest and control natural light. Deep-plan buildings can bring daylight in through atria and use angled wells and reflective surfaces to bring daylight into the core of the building to illuminate lobbies and interior circulation spaces.
- Design indoor recreational spaces, such as pools or fitness rooms, with large expanses of glazing and skylights to maximize daylight infiltration.
- Incorporate large window openings in areas of maximum daylight exposure.
- Minimize the depth of rooms and building floor plates to increase the amount of natural light entering the space.

- Increase the quantity of natural light by promoting design elements including light shelves, light ducts, and other apparatus to capture light.
- Design the development to balance and control factors such as heat gain and loss, glare, visual quality and variations in daylight availability.
- Specify low reflective interior color schemes and materials to balance visual quality and quantity.
- Consider the use of sun shades, louvers, operable blinds and draperies and exterior light shelves to control and reduce glare.
- Design frit patterns for glazing surfaces and specify glass to reduce solar heat gain while allowing natural light into the space.
- Use technology to design and implement integrated daylighting strategies throughout the development.
- Consider computer modeling software to simulate daylighting conditions and develop an effective strategy for both natural and artificial light throughout the development.
- Consider other technologies such as photo responsive controls to maintain consistent light levels and minimize the change in the quality of light from natural to artificial.
- Utilize, where applicable, daylighting to reduce the energy required for electrical lighting, being mindful that introducing daylight into building interiors may also increase solar heat gain and cooling loads.
- Ensure, when daylighting is utilized for performing specific tasks, that factors impacting the quality and quantity of daylighting within the building such as window placement and sizes, glazing transmittance, room geometry, interior surface finishes, and shadows cast from nearby buildings are taken into consideration.
- Ensure the extent and type of lighting controls relate to the function of each space, the number of occupants, the frequency of use, and the level of daylighting within each space.
- Integrate daylighting into the overall lighting approach of the building to provide a balance between natural and artificial lighting.
- Locate the maximum number of spaces near daylight through efficient interior space planning and configuration.
- Integrate building systems, including artificial lighting with daylighting through control systems.
- Sloped ceilings can direct more natural light into a space. Sloping the ceiling away from the glazed area will increase the surface brightness of the ceiling itself deeper into a space.
- Design to avoid direct beam daylight on critical visual tasks. Poor visibility and discomfort will arise if excessive brightness variations occur in the location of critical visual tasks.

FURTHER RESOURCES

Publications:

1. Baker, Nick, and Koen Steemers. *Daylight Design of Buildings: A Handbook for Architects and Engineers*. James & James Ltd, 2002.
2. Phillips, Derek. *Daylighting: Natural Light in Architecture*. Architectural Press, 2004.
3. Rea, Mark S. *The IESNA Lighting Handbook*. Illuminating Engineering Society of North America (IESNA), 2000.
4. Rutes, Walter A., et al. *Hotel Design, Planning, and Development*. W. W. Norton & Company, 2001.

6.6 [IE.6] GLARE

6.6.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.6.2 PURPOSE

To reduce the level of visual discomfort from direct or reflected glare from sunlight.

6.6.3 CONTEXT

An excessive amount of luminance within the visual field produces glare, which can cause discomfort to building occupants. The issue of glare is exacerbated when there are high-contrast situations, which typically occur when the illuminance from a window opening is significantly higher than the luminance of adjacent surfaces that are dark and of low-reflectance.

All developments should avoid excessive daylight glare, as per CIBSE LG7 & BSEN12464-1 Standards. Particular attention should be given to spaces where occupants use visual display terminals (VDT) to prevent glare.

Windows and other openings that permit daylight can produce more severe glare than artificial lighting because of the intensity of sunlight. However, appropriate glare control for artificial lighting is also important for occupant comfort and the development should specify luminaires that meet the glare and illuminance requirements of the IESNA Lighting Handbook, or equivalent.

Refer to IESNA RP-5-99 for further guidelines to reduce glare.

6.6.4 GUIDELINES

- Consider the spatial arrangement of the building and interior spaces to minimize discomfort from excessive glare and contrast.
- Manage direct sunlight and reflections from bright external surfaces through windows, glazed doors, and skylights by using light shelves, blinds, louvers, fins, shades, tinted glazing and light-scattering glazing.
- Provide adequate controls to prevent glare within the building, especially in predominantly occupied typical spaces.
- Consider the provision of mechanically operated shading devices with manual override capabilities.
- Design for low luminance ratios and appropriate lighting of interior surfaces to maximize occupant comfort.
- Ensure the lighting system meets relevant standards in terms of minimum lighting levels, light uniformity and glare control.

FURTHER RESOURCES

Websites:

1. Bickford, E. Lawrence. "The EyeCare Reports - Computers and Eyestrain." *The EyeCare Connection*, 19 Jan. 1996, http://www.eyecarecontacts.com/computers_and_eyestrain.html.

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1. Baker, Nick, and Koen Steemers. *Daylight Design of Buildings: A Handbook for Architects and Engineers*. James & James Ltd, 2002.
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4. *Lighting Guide 7: Office Lighting*. The Chartered Institution of Building Services Engineers, 2005.
5. *Lighting Guide 10: Daylighting and Window Design*. The Chartered Institution of Building Services Engineers, 1999.
6. Phillips, Derek. *Daylighting: Natural Light in Architecture*. Architectural Press, 2004.
7. Rea, Mark S. *The IESNA Lighting Handbook*. Illuminating Engineering Society of North America (IESNA), 2000.
8. *Recommended Practice of Daylighting (RP-5-99)*. Illuminating Engineering Society of North America (IESNA), 1999.
9. Rutes, Walter A., et al. *Hotel Design, Planning, and Development*. W. W. Norton & Company, 2001.

6.7 [IE.7] VIEWS

6.7.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.7.2 PURPOSE

To maximize exposure to external or internal views.

6.7.3 CONTEXT

A view of the outdoors is important for the comfort and well-being of occupants as it allows the eyes to refocus, helps to relieve eye strain and reduces visual fatigue. Unless an activity requires the exclusion of daylight, a view out-of-doors should be provided irrespective of its quality. Most people prefer a view of a natural scene: trees, grass, plants and open space. All occupants of a building should have the opportunity for the refreshment and relaxation afforded by a change of scene and focus. Even a limited view to the outside can be valuable. If an external view cannot be provided, occupants should have an internal view possessing some of the qualities of a view outdoors, for example, into an atrium. For interior zones where no direct daylight is provided the indoor nature exposure (INE) that replicates nature including plant-based features, organic textures, fish tanks, live or artificial plants, nature photography or art and sounds and aromas can be considered potential means of improving health and creating health-promoting environments.

6.7.4 GUIDELINES

- Configure the building form, interior spaces, and partitions to maximize views to the surrounding outdoor environment and consider alternative indoor views.
- Design to provide views from spaces that are regularly occupied; it is not necessary to consider those spaces that are intermittently used throughout the day such as storage rooms, copy rooms, circulation spaces, restrooms, and mechanical and custodial spaces.
- Use interior glazing, an open plan configuration, and lower partition heights to maximize views to the exterior.
- Consider arranging the plan such that spaces in frequent use are along the exterior of the building, while infrequently used spaces, including restrooms, elevator cores, and storage rooms, are contained within the core of the building.
- Consider, in the design the windows sizes, type of glazing, and placement of shading devices as these can impact the ability for occupants to have views out to the exterior.
- Ensure that views out are not impeded by the design of the façade and glazing types.
- Consider the surrounding environment and provide a view of a landscape or distant buildings if possible, to allow occupants to focus on objects rather than solely a view to the sky. The site plan should be analyzed to determine whether the proximity of buildings on adjacent sites will impede views to the exterior.
- Consider the provision of an internal courtyard, with adequate depth, to imitate views to the exterior.
- Ensure through calculations and simulations that the benefits obtained from maximizing views and daylighting will not be compromised by a significant increase in energy use.

FURTHER RESOURCES

Websites:

1. Bickford, E. Lawrence. "The EyeCare Reports - Computers and Eyestrain." *The EyeCare Connection*, 19 Jan. 1996, http://www.eyecarecontacts.com/computers_and_eyestrain.html.

Publications:

1. *Lighting Guide 10: Daylighting and Window Design*. The Chartered Institution of Building Services Engineers, 1999.

6.8 [IE.8] ACOUSTICS

6.8.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.8.2 PURPOSE

To meet the minimum acoustic performance requirements for indoor environments.

6.8.3 CONTEXT

Good acoustic performance is essential for all building typologies, from open offices to worship centers. Some workplaces are exposed to high and unsafe noise levels for the occupants. To ensure the design and construction of healthy buildings, acoustics must be considered in the design as well as in the operation phases.

Noise within buildings is received from two sources:

- Intrusion from external surroundings.
- Building services.

Typical external noise intrusion sources include traffic noise (road, rail and/or aircraft sources); mechanical plant and equipment associated with adjacent buildings and industrial activities and local activities such as markets, maintenance, sport and leisure. Building services noise includes noise sources such as fans, air-conditioning, motors and pumps etc. The noise can be transferred to internal useable spaces by two mechanisms namely; air-borne noise transmission and structure-borne noise transmission. Both mechanisms of transmission must be considered in buildings by the provision of appropriate sound insulation and structural isolation.

The design should mitigate the effects of external noise sources through the layout of the building, location on the site and the location of noise-sensitive spaces within the building plan

6.8.4 GUIDELINES

- Design the development to meet the minimum requirements for acoustic quality within the building to ensure a satisfactory level of acoustic performance. Interior noise levels should be maintained and avoid interference with the regular tasks of occupants and users.
- Consider noise generated both outside the building, on the development site or adjacent properties and noise generated from services, equipment and activities within the proposed building.
- Determine the specific requirements for each space, including privacy levels, sound isolation needs and acceptable background noise levels.

- Design for the appropriate acoustic performance levels within each area of the building.
- Use vegetation, earth berms, or other noise barriers on the site as a means of muffling off-site noise before it reaches the building.
- Specify building components with appropriate sound transmission class (STC) rating, such as exterior walls, windows, and doors, to protect interior spaces from harmful noise sources. STC is a number rating system used to compare the sound insulation properties of building elements including walls, floors, ceilings, windows, and doors. STC ratings are impacted by the height of partition walls. For cases where sound isolation and/or privacy levels are important, full-height partition construction should be specified.
- Consider using acoustical ceiling tiles and wall panels or spray-on acoustical treatments in spaces where additional sound absorption is necessary.
- Provide sufficient noise insulation to mitigate impacts from interior noise sources including those generated by plumbing systems, mechanical ventilation systems and air conditioning equipment.
- Minimize excessive vibration from services and equipment as per the ISO 2631-2 standard or equivalent to mitigate acoustic problems in the building interior.
- Separate noise-generating areas from noise-sensitive spaces within the building.
- Consider the use of soft, sound absorbent materials for interior finishes including walls, floors, and ceilings in order to reduce noise levels. A higher sound absorption rate will attenuate noise transferred from the exterior or generated within the building and will increase the acoustic performance within the building. Acoustical information can be obtained from manufacturers to help select the most appropriate and effective materials and components to meet the acoustic requirements of the development.
- Consider the floor impact sound level and the performance of sound insulation as related to impact noises both heavy and light.

EDUCATION Scheme

- Appropriate acoustic conditions in education buildings is essential to learning. Students are still developing language ability through their teens and noise affects this development. A study has shown that children are much more affected by background noise than adults as their ability to suppress echo-like sounds is still developing. In addition, noise causes teachers to speak more loudly and strain their voice.
- Some of the common sources of noise in classrooms are traffic, HVAC systems, reflective surfaces, and hallways. The design of large rooms which are divided into smaller classrooms with partitions should be avoided, as this usually produces spaces with poor acoustics.

- Program placement can have a large effect on acoustic quality. Locate noisy areas like gymnasiums and cafeterias away from more noise-sensitive spaces such as classrooms and libraries. Partition walls should extend to the structural deck, rather than ending at the suspended ceiling. Windows are often the weakest noise barriers in a building. Double glazed windows are much better at insulating a space from noise.
- Consider laminated glass for the outer panes of double-glazed windows. Many acoustic panels and tiles have reduced acoustical properties if they are painted.
- The standard reverberation time (RT) for classrooms is between 0.4 and 0.6 seconds. An RT of greater than 0.6 seconds causes echo and makes speech less intelligible. However, if too much of the sound is absorbed (generally an RT of less than 0.4 seconds), then a speaker's voice may not carry far enough. This is a particular problem in larger classrooms and lecture halls. Reverberation times should be considered for all spaces. The recommended maximum reverberation time for auditoriums is 0.8 seconds. The recommended maximum for gymnasiums is 1.2 seconds.

HOSPITALITY Scheme

- Install in each hotel suite or room, decibel level regulators on all appliances in addition to mechanical equipment including HVAC.
- Consider installing sound buffering windows to reduce traffic noise. Apart from rooms and suites, hotel facilities should remain below an overall decibel level to prevent distraction to hotel occupants. Kitchen noise, large laundry machines and gym equipment provide the largest amount of in-hotel noise pollution on average; restrict each to night time operation when possible to avoid occupant disturbance.
- Ensure the design of soundproofing guestrooms in areas situated below or above banquet rooms, restaurant/lounge spaces, sports facilities and other areas with high noise levels.
- Implement additional measures to regulate external noise transmission where hotels are located near airports or busy highways.

MOSQUES Scheme

- Special consideration should be given to the design of prayer halls to enhance acoustic quality, particularly during prayer services. Worshippers in all prayer halls, including the main prayer hall and women's prayer area, should be able to clearly hear the Imam during congregational prayers.

FURTHER RESOURCES

Publications:

1. *ARI 885 Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets*. Air-Conditioning, and Refrigeration Institute (ARI), 1998.
2. *BS 8233:1999 Sound Insulation and Noise Reduction for Buildings. Code of Practice*. British Standards Institution, 1999.
3. *BS EN ISO 140-4:1998 Acoustics - Measurement of Sound Insulation in Buildings and of Building Elements - Field Measurements of Airborne Sound Insulation Between Rooms*. British Standards Institution, 1998.
4. *BS EN ISO 717-1:1997 Acoustics. Rating of Sound Insulation in Buildings and of Building Elements. Airborne Sound Insulation*. British Standards Institution, 1997.
5. *BS EN ISO 717-2:1997 Acoustics. Rating of Sound Insulation in Buildings and of Building Elements. Impact Sound Insulation*. British Standards Institution, 1997.
6. *Football Stadiums: Technical Recommendations and Requirements*. Fédération internationale de football association (FIFA), 2007.
7. *ISO 2631-2:1989 Evaluation of Human Exposure to Whole-Body Vibration - Part 2: Continuous and Shock-Induced Vibrations in Buildings (1 To 80 Hz)*. International Organization for Standardization, 1989.
8. Office of the Deputy Prime Minister, United Kingdom. *Resistance to Sound: Approved Document E*. 2003.

6.9 [IE.9] LOW-VOC MATERIALS

6.9.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.9.2 PURPOSE

To maximize the use of certified Low Volatile Organic Compound (VOC) materials.

6.9.3 CONTEXT

Many materials used in construction, such as paints, shellacs, insulation, sealants, and other materials used especially in finishes, have a VOC content. These materials have chemicals additives that readily vaporize (become volatile) at typical compounds have a low evaporating point, and typical indoor temperature and pressure conditions. Common VOCs include formaldehyde, benzene, flammable alcohols, cleaning solvents, etc.

VOCs can pose risks to human health and have negative effects on the indoor environment. Research shows that high concentrations of VOCs indoors are linked to an increase in allergies, asthma and other respiratory diseases, especially affecting children. VOCs also cause discomfort to occupants in the form of odor. In contrast, low-VOC materials are formulated to reduce "off-gassing" of potentially hazardous vapor emissions.

Standards related to the levels of VOC emitted from materials have been developed to support the decision-making process towards specifying materials with desirable healthy attributes.

Societal awareness of this problem has increased during the past few years; hence many low-VOC building materials have been developed and are now available in the market. For exampel, the performance of low-VOC latex paint has remarkably improved and its quality is equivalent or even surpassing the solvent-based paints at matching prices. Other low-VOC building materials are increasingly formulated to outperform their more volatile conterparts products such as composite-wood systems, coatings and sealants.

To mitigate the impacts of VOC containing materials the construction industry should make positive steps towards maximizing the use of low-VOC materials.

6.9.4 GUIDELINES

- Specify materials that have a zero rate of volatile organic compound (VOC) emissions to minimize the health risks associated with indoor air contaminants. Indoor materials to be considered are the following: paints, coatings, primers, finishes, stains, sealants, caulking, adhesives, carpets, and composite wood products.
- Avoid composite wood and agrifiber products that contain urea-formaldehyde resins. Many alternatives to composite wood are available including recycled plastic, salvaged wood, oriented strand board (OSB), and certified wood. Bio-composites are also available; however, they should not be used in moisture prone areas. Low density fiberboard, a good option for tack boards, is made from 100% recycled paper.
- Specify the smallest amount of adhesive possible. Also, when possible, have boards cut off-site in a space with adequate ventilation.
- Use Low-VOC materials for any indoor surfaces, such as flooring, walls, and ceilings and those used within wall cavities, above suspended ceilings, and below finished floors.
- Avoid the use of materials that may emit harmful contaminants into the indoor environment for indoor furnishings, mechanical system components, and any other systems or components within the building.

FURTHER RESOURCES

Websites:

1. *The Carpet and Rug Institute*. https://carpet-rug.org/. Accessed 4 Sept. 2019.

Publications:

1. *Core Criteria for High Performance Schools*. Vol. 3, Collaborative for High Performance Schools (CHPS), 2006, https://chps.net/best-practices-manual.
2. *Design for High Performance Schools*. Vol. 2, Collaborative for High Performance Schools (CHPS), 2006, https://chps.net/best-practices-manual.
3. *GS-11 Green Seal Standard for Paints, Coatings, Stains and Sealers*. Green Seal Inc., 2015.
4. *GS-36 Green Seal Standard for Adhesives for Commercial Use*. Green Seal Inc., 2013.

6.10 [IE.10] AIRBORNE CONTAMINANTS

6.10.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

6.10.2 PURPOSE

To provide measures for the control of potentially hazardous airborne contaminants.

6.10.3 CONTEXT

The indoor air quality of a building is susceptible to airborne contaminants including hazardous particulates and chemical/biological materials, the presence of which, in an uncontrolled manner, can present a significant risk to human health and well-being.

Several sources for generating and transferring airborne contaminants are encompassed in buildings including, but not limited to, the following: pedestrian traffic into the building can introduce contaminants in the form of debris, dirt and dust; air handling units used to exchange both return air and outside supply air; building interior finishes allowing for the growth of fungus, mold and bacteria, water related systems and equipment including cooling towers and treatment systems potentially harboring waterborne bacteria and parasites.

Careful management and considerations must be implemented to mitigate the risks associated with these sources of contamination.

6.10.4 GUIDELINES

- Incorporate an entryway system with grilles, grates, or other effective systems to capture potentially harmful particles as occupants enter the building.
- Select and design entryway systems with a recessed floor area for collecting debris and particles as users enter the building. Systems with a recessed floor area allow for easier maintenance and cleaning and are more effective than other systems such as carpeted entryways.
- Isolate physically areas that may generate harmful contaminants from the mixing and storage of chemicals, such as maintenance and custodial spaces.
- Isolate high-volume copier, fax, and printer operations from other occupied spaces as these activities can generate harmful contaminants.
- Separate adjacent spaces from areas with potential contaminants using deck-to-deck partitions or sealed gypsum board enclosures.

- Use dedicated exhaust systems in areas containing potential contaminants and utilize negative pressurization to prevent contaminants from entering adjacent spaces and the building's main ventilation systems.
- Utilize high-level filtration systems for air handling units that process both return air and outside supply air.
- Select air handling units in part for their capacity to accommodate required filter sizes and pressure drops.
- Ensure easy access to air handling units for regular servicing and maintenance.
- Select appropriate interior finishes that possess the capacity to prevent the growth of fungus, mold, and bacteria on building surfaces. Indoor materials should resist microbial growth.
- Consider specifying hard surfaces, such as tile and wood flooring rather than carpets, as they are easier to maintain and clean.
- Design the building envelope with effective moisture barriers to prevent water from seeping into the building and to protect interior materials and finishes.
- Minimize the risk of Legionella through the proper design and location of wet cooling towers and building water treatment systems. Legionella bacteria can move into the building through outside air intakes and pose a serious health risk to building occupants.

LIGHT INDUSTRY Scheme

- In light industrial facilities, any areas where contaminants and sources of pollution are handled must be isolated and properly ventilated. Provide ventilation systems to ensure that the air quality levels in operational areas meet or exceed acceptable levels for worker health and safety. Use exhaust equipment and containment measures in close proximity to equipment and processes to reduce the amount of contamination that enters the spaces. Ensure that ductwork and other equipment handling potentially contaminated air is properly sealed or isolated.
- Production and processing areas in light industrial facilities must be isolated from offices and other support areas because those spaces are not usually designed to handle indoor contaminants. Walls and windows should be sealed properly to avoid air leakage between the two spaces. Keep office areas at a positive pressure to further reduce infiltration. Mechanical systems that support the two areas should also be separated to avoid any contaminated air exhaust mixing with the fresh air intakes.

FURTHER RESOURCES

Websites:

1. "Green Seal; The Mark of Environmental Responsibility." *Green Seal*, https://www.greenseal.org/. Accessed 4 Sept. 2019.
2. US EPA, OCSPP. "Chemicals under the Toxic Substances Control Act (TSCA)." *US EPA*, 29 Apr. 2015, https://www.epa.gov/chemicals-under-tsca.

Publications:

1. *ANSI/ASHRAE 52.2-1999 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1999.
2. *ASHRAE 12-2000 Minimizing the Risk of Legionellosis Associated with Building Water Systems*. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2000.
3. Bennett, K. M. *Efficient Humidification in Buildings - Application Guides*. Building Services Research and Information Association (BSRIA) Ltd, 1995.
4. *Legionnaire's Disease: Control of Legionella Bacteria in Water Systems: Audit Checklists*. Health and Safety Executive, 2003.
5. *Minimising the Risk of Legionnaires Disease - TM 13*. The Chartered Institution of Building Services Engineers, 2013.

7.0 CULTURAL & ECONOMIC VALUE

The Culture & Economic Value category is concerned with the cultural impacts in the design of the built environment and support of the national economy.

The architecture of the built environment can contribute towards the preservation of local cultural identity and heritage. Design expression should align with and integrate the development into the existing cultural fabric. In addition, the use of local materials and local workforce contributes towards the growth of the national economy.

CRITERIA IN THIS CATEGORY:

CE.1 Heritage & Cultural Identity

CE.2 Support of National Economy

7.1 [CE.1] HERITAGE & CULTURAL IDENTITY

7.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

7.1.2 PURPOSE

To encourage design expression in alignment with heritage and cultural identity.

7.1.3 CONTEXT

Several countries have experienced tremendous growth in the development of the built environment in the past several decades. With this rapid growth and change of cities and landscapes, countries must address how to preserve their cultural identity, heritage and resources and define the role each plays in the formation and continuity of a cultural and national identity. Vernacular architecture is an architectural style developed based on local needs, the availability of building materials and which reflects local traditions. In this context, the conservation of heritage in the region is not a new pursuit. In the spring of 1985, the Arab Urban Development Institute (AUDI) worked with the Arab Towns Organization (ATO) and the Union of Municipalities of Marmara Region to discuss many of the pressing questions facing the region today. During "The Conference on the Preservation of Architectural Heritage of Islamic Cities," participants raised questions regarding city planning, historic preservation and new architecture and development. The conference addressed methods of conservation and focused on the question of cultural and national identity.

While past studies have laid much of the conservation framework for addressing architectural and urban scale, it is important to learn from the limitations of prescriptive preservation systems. Preservation is the process of maintaining living contact with the past through identification, transmission and protection of that which is considered culturally valuable and therefore worthy of retaining. Often, the emphasis is on formal concerns, for example architectural style and the result can be superficial. Central to any system of cultural preservation should be an understanding of the plurality of the culture within the region and the identification of cultural values. Not only will cities have culturally distinct regions and neighborhoods, but there will be architectural diversity within individual districts. Complexity and diversity within a culture underlines the need for the careful review on a case by case basis, rather than a restrictive overarching approach. According to the Aga Khan, "The loss of [this] inheritance of cultural pluralism—the identity it conveys to members of diverse societies, and the originality it represents and stimulates in all of them—will impoverish our societies now and into the future."

A common method of preserving cultural identity in some cities is through the creation of "historic districts." At best, these protected areas are highly successful livable neighborhoods; in the worst cases, they can resemble "reconstructed villages"—protected enclaves that draw much tourism but ultimately are little more than theme parks. Urban designers now agree that cities, like living organisms, grow incrementally and are most successful when their growth is diachronic, including both old and new. It is equally important for any urban plan to be flexible and adaptable to accommodate change. It is a fine balance of preserving the old, encouraging the new, including the traditional and the innovative, that makes urban life socially, economically and aesthetically vital while maintaining cultural continuity and prosperity.

Architectural context

The style of the architectural heritage is similar throughout the region. The Qatari, or Gulf style, is a hallmark of the identity of the place known as the Gulf, which specifically includes the countries that border the Arabian Gulf to the east or west, Iran (or what is known as Fariss) and countries west of the Arabian Peninsula's shores bordering the Gulf.

The local style is distinct and has characteristics and an identity that cannot be mixed with the styles that surround it. For example, venturing deep into the Arabian Peninsula (the area of Najd specifically), differences in style, construction materials, climate, and culture can be observed. This change also occurs in Iran, where a different culture and style emerges travelling inland from the Persian shore.

The architectural style in Qatar and around the region is the result of a group of influences, factors and forces that shaped the local style over many years. These agents can be divided into two realms: social, cultural, religious, or spiritual influences and climatic, geological nature, or materialistic components.

After centuries of development, the Gulf style attained a distinct identity during the middle of the twentieth century. In the mid-twentieth century, new influences emerged due to the economic boom from oil production in the area, and the arrival of architects and contractors from different cultures that introduced new construction technologies and materials such as cement.

The character and the cultural, social, and religious values of the Arabic-Muslim community in the Gulf have contributed to the space planning and layout of the typical house. For example, Al-Majlis, where the owner of the house would meet his guests, is an important component that provides the guests with hospitality and lodging in this space without compromising the privacy of his family. Al-Majlis is located near the entry and separated from the house by a bent entrance (named Dehleez) that serves to block the guests from the yard of the house while still allowing the guests to freely enter and exit the space, as necessary.

Climate in the Gulf area

At the Tropic of Cancer, the climate is dry and humid depending on the time of year, and the wind direction most of the year is North-Western, delivering heat and humidity during the summer. The summer breeze blows during May and June, hot and dry with dust. The Autumn season (known as Al-Sfari season) starts in October, bringing rain. Winter follows with a sharp drop in temperature and cooler northerly winds (Shamal).

The seasonal climate has clearly influenced the planning of the typical house. The orientation of the house and the openings are designed to attract the desired breeze, while protecting the house from the hot breeze and the dust in the summer, or the cold northerly winds in the winter. Climatic awareness is equally shared among the Gulf residents and users of the buildings, and the architects and contractors who design and build them. The exploitation of the positive climatic conditions, while protecting areas from the negative climatic effects, resulted in highly efficient space planning and the lack of electricity was not a hindrance in making the region habitable.

Geological nature and building materials

The geological nature and properties of the building materials in this part of the world greatly affected the formal language of the buildings. For centuries, architects and masons honored the practice of building with local stone and mud mortar, transferring their technological expertise to future generations of builders. Due to the properties of stone and mortar, builders could not build walls more than one meter high in a single day. Instead, they had to wait for the mortar to dry and then proceed higher in daily increments.

Later, column and beam technology emerged, saving both time and construction materials. This method clearly expressed the structural nature of the columns and beams, allowing them to remain visible on the interior and exterior of the building. The column (50 cm x 50 cm) was the optimum size for stone and mud infill, but the use of horizontal beams (Jussur) was essential to stabilize the columns and prevent the walls from collapsing. After reaching a height of two meters, the mason would place wood beams that at the time were imported from east Africa, to horizontally brace the wall. This process was repeated up the wall and a top cross-beam helped stabilize the roof. The spaces between the columns were usually between 90 cm-100 cm and had different uses depending upon the homeowner's budget.

The structural form and the nature of the construction materials lends a unique aesthetic to the architecture of the region. Therefore, the Gulf architectural style can be called "structural architecture" as the columns and beams are clearly visible and define the structural plan. The interpretation of this style in many new works has resulted in unintended misrepresentation and distortion, due to a lack of accurate scientific references for architects and designers.

Gypsum used in plaster is expensive to mine and import, therefore it was used according to the owner's budget. Sometimes it was used in important spaces, such as Al-Majlis (the male guests' reception area) and the entryway of the house, or it was used for the decoration of columns and parapets. The elements of decoration and ornamentation in Gulf architecture are distinct and have features that cannot be confused with the arts of the surrounding areas. Nevertheless, the scarcity of scientific examples required to create an elaborate and objective reference of ornamental motifs in the Gulf style often results in confusion and cultural misappropriation.

Regional architecture is absent of color except for the color resulting from the gypsum plaster on the walls of the house. The coloration that is seen is the result of the interaction of the gypsum with the natural elements.

Despite the lack of variations in color, the façades of the buildings are enriched with alternating recesses and protrusions. The shaded verandah, or Al-Laywan, is recessed deep (about three meters) from the exterior sunlight and creates a very dark shadow. The walls built between the columns are recessed about ten centimeters from the face of the columns, casting shadows that create elegant lines over the building façades.

7.1.4 GUIDELINES

Urban level

- Urban Form and Structure: This includes the street pattern and forms of development. The scale, alignment and hierarchy of buildings should be considered—for example, the use of compact, urban form. It is also important to study areas of enclosure and convergence. Both form and structure may be affected by the natural topography of the area.
- Uses and Patterns of Activity: This is the range and nature of activity. The commercial and residential tradition and the use of the ground floors is very important in adding a cyclical dimension and variety to the neighborhood.
- Neighborhood Dimension: Consider pedestrian and vehicular traffic and the scale of experience. Factors to consider include the width of streets and sidewalks, street furniture, landscaping and whether vehicular traffic should be allowed.
- Open Space: Consider the role of open/public space and why it exists in the city or development as places for people to gather and interact.
- Archaeological Sensitivity: Consider if there any landmark buildings on the site which are historically protected or need historical protection. Determine if the site is of archaeological importance and assess the extent of permissible new development.
- Urban Response to Natural Environment: Assess how wind and sunlight are regulated at an urban scale. Consider the width and orientation of streets in relation to the direction of prevailing winds and solar position. Shade can be provided with narrow streets and strategically placed buildings and vegetation.

Building level

- Facades: Consider the rhythm of buildings, windows, and openings. This should influence the design and composition of the façade and other elements along the street.
- Height: Consider the height of new buildings relative to the existing streetscape.
- Scale: Consider the form and scale of new development relative to the form and scale of existing buildings. This is related to but distinct from height as it is relative to the size of the human body and experience of the user. It can be affected by proportion, massing, composition and the setback from the street. Review the scale and proportion of building elements (arches, columns, etc.) and how they relate to each other and the overall composition and space of the building as a whole.
- Lighting: Assess how the building or development will appear at night. Consider the intensity, placement, and color of light. Carefully consider what aspects of the architecture are to be highlighted.

- Style: Review how the building relates to the architectural style of the region and surrounding buildings. It does not need to replicate the style; however, there should be a sensitive response to the style of the existing architectural context.
- Material/Color: Consider the material and color of buildings and surfaces; how the material and color will age, and if this will affect how the building continues to relate to the surroundings. Using local materials and trades is preferable to maintain both cultural and economic value.
- Space: Consider using open space, for example, courts and liwans (galleries) and assess how these spaces relate to more private spaces and to the entry sequence.
- Building Response to Natural Environment: Assess how wind and sunlight are regulated at a building scale. The orientation and placement of buildings in relation to the direction of prevailing winds and solar position greatly influences how they will react to the natural environment. Ways to regulate the environment include natural ventilation, the use of courtyards, and strategic shading.

Innovation

- Outstanding contemporary design can be influenced by and based upon an understanding of local vernacular planning and architecture.

MOSQUES Scheme

- Historically mosques have simple designs. Influenced significantly by the climate, mosques are characterized by thick walls that minimize heat gain from the sun. Courtyards provide a comfortable space outdoors and many prayer halls have entryways shaded with a portico. A common feature of traditional Qatari mosques is the open liwan, or external prayer hall, usually located between an inner liwan and a courtyard. This style is developed from the original hypostyle mosque type, started in the prophet mosque in Madina, and widely implemented in MENA region. The entrance to the mosque is typically through the courtyard, with the minaret at one corner of the site plan.
- Consider community involvement in the design of the mosque. A mosque expresses a collective identity that is tied to both the local community and the global community of Islam. Input from the congregation can help in the development of mosque designs that appropriately express the community and region.

FURTHER RESOURCES

Publications:

1. Holod, Renata, and Hasan-Uddin Khan. *The Contemporary Mosque: Architects, Clients, and Designs since the 1950s*. Rizzoli International Publications, 1997.
2. Jaidah, Ibrahim, and Malika Bourennane, editors. *The History of Qatari Architecture 1800-1950*. Skira, 2010.
3. Kahera, Akel, et al. *Design Criteria for Mosques and Islamic Centers*. Architectural Press, 2009.
4. "The Principles of Traditional Design of Mosques." *Proceedings of the Symposium on Mosque Architecture*, vol. 10, 1999.

7.2 [CE.2] SUPPORT OF NATIONAL ECONOMY

7.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

7.2.2 PURPOSE

To maximize the value of construction expenditures benefitting the national economy.

7.2.3 CONTEXT

Procurement of goods or services delivered or manufactured and assembled within the country contribute towards economic growth and provide opportunities for employment.

The concept of a circular economy in the built environment creates a more sustainable, efficient, and resilient economy. The construction industry contributes significantly to the national economy as it encompasses the utilization of versatile supply chain elements including the procurement of materials, workmanship provisions, manpower supply and use of resources.

Domestic sources are, in general, more accessible to end users than 'imported sources'. Products or services can be delivered in less time compared to external foreign sources. Communication with local businesses including after sales, exchange or refunds of faulty merchandise can be easier than with international suppliers. Less transportation between the supplier and end user may also result in cost benefits due to lower transportation costs and environmental benefits due to less GHG emissions and fossil fuel depletion.

Employment opportunities for local people will increase as a result of domestic sourcing due to the growth on demand for local goods and services which, in turn, will create increased job opportunities to meet the new demand.

The national economy shall benefit from the increase in domestic sourcing for labor force and goods due to the increase of the circular flow of income. An increase in demand for domestic sourcing can result in more people being hired by local suppliers to meet the increasing demand. These new workforces will spend more money in the local economy producing a positive multiplier effect. In addition, local sourcing encourages more entrepreneurs to start small businesses which will contribute to the growth of the economy.

7.2.4 GUIDELINES

- Develop a plan to utilize and employ local companies and firms where possible and investigate the availability of products and services in the local market.
- Procure construction-related products, materials and equipment from domestic sources to support the local economy.
- Procure construction-related services including contracting, consulting, project management and other professional services from domestic sources to benefit the local economy.
- Ensure that procurement practice provides opportunities to engage local entrepreneurs and new businesses in the delivery of the development.
- Ensure that priority is given to locally manufactured/assembled products over similar products manufactured abroad.

FURTHER RESOURCES

Publications:

1. Adjei, A. B. "Sustainable Public Procurement: A New Approach to Good Governance." *Proceedings of Green Procurement*, International Public Procurement Conference, 2010.
2. Appiagyei, Ama, et al. "Environmental Considerations in Procurement Decisions: A Literature Review." *Sustainability in Environment*, vol. 1, 2016, p. 40, doi:10.22158/se.v1n1p40.
3. Chartered Institute of Purchasing & Supply. *Sustainability in Supply Chains*. Profex Publishing, 2012.
4. Nijaki, Laurie Kaye, and Gabriela Worrel. "Procurement for Sustainable Local Economic Development." *International Journal of Public Sector Management*, 2012, doi:10.1108/09513551211223785. world.

8.0 MANAGEMENT & OPERATIONS

The Management & Operations category is concerned with the design of the development for use during the operational phase. The development should plan for and implement sustainable and effective building management and operations practices.

Sustainable building management and operations can mitigate environmental impacts such as water depletion, materials depletion and human comfort and health.

CRITERIA IN THIS CATEGORY:

MO.1 Systems Commissioning

MO.2 Waste Management

MO.3 Facility Management

MO.4 Leak Detection Systems

MO.5 Automated Control System

MO.6 Transportation Systems in Building

8.1 [MO.1] SYSTEMS COMMISSIONING

8.1.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

8.1.2 PURPOSE

To develop and implement a commissioning process that ensures the delivery and performance of the systems within the development.

8.1.3 CONTEXT

Building commissioning (Cx) is a process to verify all, or a number of the subsystems for electro-mechanical, plumbing, fire/life safety, building envelope, interior systems, utility plants, lighting, wastewater, controls and building security to achieve the project requirements as determined by the development owner and the consultant design team. Commissioning is quality-focused and necessary in construction projects as it ensures that systems are planned, designed, installed, tested for future operation and to work to the best of their ability.

Commissioning, when introduced at the start of the design process, is most effective and is one of the most significant factors to ensure long-term success.

The commissioning plan can include the following key commissioning activities:

- Establishment of Commissioning Scope
- Establishment of Commissioning Program
- Establishment of Commissioning Schedules
- Establishment of Testing and Inspection Plans
- Development of Commissioning Specifications
- Determination of Special Testing Needs
- Determination of Operational Staff Training Needs

Commissioning is now a common practice as building owners and developers demand more from their investment. The primary objective of the commissioning process is to improve the development from design through post construction and occupancy.

The commissioning authority or commissioning agent (CxA) is often directly contracted to the development owner to ensure an unbiased performance of the CxA. The CxA may be an employee of the development owner or a subcontractor, architect, engineer, test and balance contractor, or other trade contractor for specific trade testing. Best practice recommends that the CxA be contracted and maintained throughout the design, construction, and handover of the development to identify possible operational, installation, testing, and performance issues before they become a potential construction issue. The CxA works closely with the owner, design team, principal contractor and sub-contractors and is responsible for leading and managing the project commission process working closely in a co-operative work environment focusing on teamwork throughout the design, construction and post construction phases.

Typically, the CxA prepares the commissioning specification and commissioning plan during the development design phase. The commissioning plan is a live document to outline the commissioning processes and expectation based on the Owner Project Requirements (OPR), the Basis Of Design (BOD) and the construction documentation including drawings and specifications.

8.1.4 GUIDELINES

- Consider introducing a commissioning program at the commencement of the project as this can be one of the significant factors for the long-term success in the post-occupancy operational phase.
- Appoint a qualified commissioning party to be responsible for leading the commissioning process, coordinating with the development team throughout the design and construction phases to ensure proper implementation.
- Develop the OPR in conjunction with the project owner and ensure the requirements are quantifiable and measurable to verify that the development objectives will be achieved.
- Ensure the commissioning plan covers all major building systems including but not limited to:
    - HVAC systems.
    - Lighting systems and controls.
    - Electrical systems.
    - Water-use systems.
    - Renewable energy systems.

- Undertake all necessary measures to ensure that all systems are planned, designed, installed, tested and operated to work to the best of their ability under projected occupancy loads and conditions.
- Develop a plan to address the coordination between team members of all phases, including design, installation, and operation. Coordination between phases is necessary to maintain the performance of the building's systems at the maximum efficiency throughout the life of the building.
- Ensure that the commissioning process addresses the performance criteria for each system. The appointed party will review the necessary documents, such as design documents, submittals, and field-testing reports, to verify that the building systems are properly designed and installed to perform efficiently.
- Review and verify that the commissioning requirements have been included within the construction documents and development specifications.
- Prepare a commissioning report documenting necessary observations and evidences for the outcomes of the commissioning processes and procedures implemented as determined in the OPR.

FURTHER RESOURCES

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8.2 [MO.2] WASTE MANAGEMENT

8.2.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

8.2.2 PURPOSE

To provide measures for the implementation of waste management best practice during the post-occupancy phase.

8.2.3 CONTEXT

Solid waste management (SWM) is one of the important health and environmental issues the world is currently facing. The primary causes of waste production include an increasing population combined with an expanding rate of resource consumption.

Society can opt to reduce the amount of waste taken either to landfill or for incineration by adopting a solid waste hierarchy as follows:

- Reduce.
- Reuse.
- Recycle/composting.
- Disposal, when none of the other options are feasible.

Organic waste is material that is biodegradable from plant or an animal sources. Organic waste is usually broken down over time by other organisms and is often referred to as wet waste. Generally, organic waste comprises vegetable and fruit debris, paper, poultry, fish and meat remains and human waste which quickly disintegrate. Organic waste, the main stream of waste generated, accounts for 50% to 60% of the municipal solid waste with very little being composted. Composting is a practice that can significantly mitigate the health and environmental issues associated with waste generation. Organic waste is more biodegradable than inorganic materials, and the by-products produced after organic waste has been broken down can be used for composting and enriching the soil.

The growth in the industrial-related sector has caused an increase in the generation of hazardous waste. This also poses a risk to human health and habitat contamination. Deviation of hazardous waste from landfill is essential to avoid such major health and environmental impacts.

8.2.4 GUIDELINES

Organic waste

- Develop an organic waste management plan for the collection, storage, composting and/or recycling of the various organic waste streams.
- Provide sufficient space for sorting and storage of the various organic waste streams.
- Provide sufficient collection points for organic waste throughout the building, especially near concessions and other food service locations where most of the waste is produced.
- Provide collection bins for various waste streams to ensure building users can easily separate organic waste.
- Consider specifying self-closing airtight systems in areas containing organic waste to prevent risks to human health. These systems could be designed to be operated either automatically or manually, depending on user preference and their intended use.
- Allocate a central sorting and storage area for waste materials.
- Ensure that the sorting and storage areas are properly contained and ventilated to avoid the dispersion of noxious fumes and odors into occupied spaces of the building, which could present a possible health risk or discomfort to building occupants and users.
- Locate the organic waste storage spaces close to a vehicular access to facilitate collection and removal.
- Consider, if feasible, the on-site composting of organic waste.
- Identify off-site facilities where organic waste can be transported. These off-site locations can be municipal facilities that handle and distribute large quantities of organic material and other smaller facilities that can reuse the material themselves.
- Ensure that all the organic waste material that is generated and collected can be used either on- or off-site.
- Consider using the biomass of generated organic waste as energy. Organic waste generates heat as it is broken down and this energy can be harnessed to provide heat and power for the building.
- Consider, if feasible, the recycling of kitchen generated cooking grease. This grease is not easily disposed of in sewers or landfills and can instead be reused for various processes. For example, vegetable-based kitchen grease can be used in biodiesel-run machines, or other useful applications.

Non-organic and non-hazardous waste

- Facilitate the collection of recyclable materials such as glass, plastics, paper, cardboard and metals.
- Provide facilities for the collection and storage of recyclable materials generated during the operational phase of the development to reduce the amount of waste taken to landfills or for incineration.
- Consider the size of equipment and facilities to be used for recycling management, for example compactors and wheeled bins, when allocating and designing the collection and storage spaces.
- Consider various recycling management equipment and strategies including recycling chutes, compactors, balers and individual collection bins located throughout the building to promote and encourage recycling activities.
- Ensure that the collection and storage spaces are clearly labeled for recycling, easily accessible to occupants and facility operators and situated close to vehicular access to facilitate collection and transport.
- Design properly contained and ventilated sorting and storage areas to mitigate the impact on the building's indoor environmental quality in terms of unwanted odors and disruptive noises from recyclable materials.
- Ensure that the signage within recycling facilities demarcate the bins for various materials to avoid contamination and improper sorting.
- Evaluate possible security measures in cases where recyclable materials may be of a high value.
- Ensure the storage capacity will be sufficient for the anticipated amount of recyclable materials generated during normal building operations.
- Develop an instruction manual/booklet to educate building occupants and facilities operators on appropriate recycling procedures to maximize recycling rates.

Hazardous waste management

- Provide hazardous waste sorting and storage areas in a secure space separate from non-hazardous waste and away from any sources of ignition.
- Provide separated storage areas for different types of hazardous waste to avoid adverse chemical reactions and potential accidents.

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8.3 [MO.3] FACILITY MANAGEMENT

8.3.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

8.3.2 PURPOSE

To provide measures for the implementation of facility management best practice during the post-occupancy phase.

8.3.3 CONTEXT

The International Facility Management Association (IFMA), defines Facilities Management (FM) as a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology. It is a process of managing and maintaining the facilities, which includes but not limited to office/living complexes, physical resources, site and any other electro-mechanical systems and utilities for the welfare of building occupants and users.

The benefits of adopting best practice in FM include financial savings related to avoiding costs due to ignorance of adequate preventive maintenance and increase in return on investment, personnel retention by maintaining a safe, comfortable and pleasant environment and core business performance due to well-maintained and uninterrupted business operations.

FM is focused on the efficient and effective delivery of support services and is a vital component in the support of an organization to undertake its core business by providing a safe and effective environment in which to operate.

The necessary provisions for the implementation of adequate FM in the post-occupancy phase include but not limited to: environment health and safety, fire safety, security, maintenance and testing, maintenance and cleaning of building fabric and janitorial services.

8.3.4 GUIDELINES

- Consider a commitment to GSAS Operations if the level of facilities management services cannot be established during the design and construction phases.
- Consider the storage of chemicals and cleaning products associated with janitorial services.
- Provide a secure room if the building typology requires such space.
- Provide easily accessible space of adequate area for general or specific storage.
- Ensure that all fire systems are adequately designed and implemented with required provisions for maintenance, inspection and testing.
- Ensure necessary security provisions are implemented for CCTV, access control and general building security requirements based on the building typology and operational phase needs.
- Develop the Operations & Maintenance (O&M) manuals for all systems and equipment specific to the development.
- Provide adequate provisions to facilitate the works associated with the building fabric maintenance which may include all preventative, remedial and upgrade works required for the upkeep and improvement of buildings and their components.
- Provide adequate janitorial storage space in terms of area and ventilation.

FURTHER RESOURCES

Websites:

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8.4 [MO.4] LEAK DETECTION SYSTEMS

8.4.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

8.4.2 PURPOSE

To install leak detection systems for major water supply and refrigerant pipes.

8.4.3 CONTEXT

Owners and managers of office buildings and other commercial properties face many unique problems related to undetected water leaks. With most office buildings and spaces being unoccupied overnight and on weekends, the potential for catastrophic water damage, high insurance claims and reduced revenue is very real.

Water damage is one of the leading causes of insurance claims exceeding, in some cases, fire and theft claims combined. However, the latest advancements in water leak sensing and shut-off technology can uncover risk for building owners and managers. With air-conditioning refrigerants, fire water pipes, pantries, windows, ceiling, etc, the potential leak sources are both inside and outside the rooms. Occasionally the leak of water or refrigerant can be dramatic while in other instances the leak can be slower and over an extended period of time, often in hidden or concealed spaces.

Aside from the adverse environmental effect of water and refrigerant leaks, the provision of water and refrigerant leak detection systems help with property (damage) protection and the maintenance of critical systems (continuous) operation (e.g. bank datacenter/s). In addition, the detection systems should assist the building facility manager and maintenance staff to establish a precise location of the leak, ideally within a short time of detection.

Effective leak detection systems must be capable of detecting major leaks which otherwise might go undetected, thereby reducing the impact on water consumption and depletion and reducing the emission of refrigerants to the atmosphere.

8.4.4 GUIDELINES

- Undertake an assessment for the water and refrigerant networks in the development to determine the potential locations for leaks and identify the associated leak detection mitigation measures.
- Provide a leak detection system to cover the building(s) and site incoming/outgoing water supply lines and specific areas within the building where a major water leak might go undetected.
- Provide a refrigerant leak detection system to cover all refrigerant based cooling systems containing more than 200g refrigerant charge.
- Specify systems that offer the advancements in wireless and monitoring technology in addition to capabilities that work well within the specific building portfolio being considered
- Consider automated shut-off valves. Automatically shutting off a water valve when a leak is detected can be very valuable to building owners if the property does not have 24/7 monitoring or the potential water source is close to critical equipment.
- Identify problem areas where wireless leak detection can be of most benefit. Wireless water leak sensing ensures any development can be fitted with sensors.
- Consider cloud-based sensors to be placed at sites of potential risk. Cloud technology supports the combination of data from all units into a single portal that can be monitored by building operators. Additionally, cloud-based management will not be interrupted by power outages.
- Ensure the leak detection systems are BMS connectable.
- Select leak detection systems that are not prone to false alarms.
- Consider the installation the leak detection systems that are capable of signalling an alarm, through the BMS to ensure the building facility operators are alerted of the leaks.
- Ensure that the water detection system can detect higher than normal flow rates for longer than a pre-set period.
- Consider combining water leak and water sub-metering systems into one system
- Consider, if feasible, the use of a dedicated built-in refrigerant detection system as opposed to using a signal generated by refrigerant auxiliary (pressure loss) contacts.
- Consider, if feasible, specifying a system with an automatic isolation and containment of the remaining refrigerant facility (auto pump-down) in addition to the leak/no-leak detection alarm.
- Ensure both duty and stand-by refrigerant based cooling systems are covered by the refrigerant leak detection system

FURTHER RESOURCES

Publications:

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8.5 [MO.5] AUTOMATED CONTROL SYSTEM

8.5.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

8.5.2 PURPOSE

To provide automated control system(s) that optimize the operational performance of the facility.

8.5.3 CONTEXT

A building management system (BMS) is a computer-based control system provided in buildings to control and monitor the building mechanical and electrical systems, including cooling, lighting, irrigation, fire and life safety systems, security systems, etc. The implementation of an automatic control system should be customized and based on the specific installed systems in a building to create a central interface of data collection and controls systems. The BMS consists of a variety of components and can significantly reduce energy consumption and increase occupant comfort by integrating and optimizing the performance of multiple systems. A further benefit of the BMS is the recorded data available to facility managers. This data is essential for calibration and optimization and can alert the facility manager to critical maintenance issues.

BMS systems are now based on open communications protocols and can be WEB enabled thus enabling the integration of systems from various third-parties and accessible from anywhere around the world.

8.5.4 GUIDELINES

- Use BMS to maximize energy savings in buildings. BMS software nowadays offer a great degree of flexibility, for instance, it may allow individual occupants to have desktop control over their task lighting (which reduces the need for a heavy general overhead lighting system), or, for instance, cooling system set point temperature needs can be adjusted by zone to respond to specific zonal heat gains.
- Consider use of a BMS enabled air quality monitoring system to be able to manage airborne contaminant levels and purify the air.
- Ensure that the BMS has the capability to control lighting systems as they consume a significant amount of energy. The BMS may employ daylight harvesting technologies to manage energy usage and occupant comfort levels. With a careful balance of natural and artificial lighting, a building can benefit from considerable energy savings and an improvement in spatial quality.

- Install sensors to monitor and automatically adjust lighting levels to favor the usage of natural light, and make sure artificial lights have controls to respond to these adjustments. To optimize lighting, it is necessary that daylight sensors cover an appropriate area.
- Select appropriate shading systems, such as blinds and louvers, to work with the BMS and place sensors in appropriate locations relevant to these systems.
- Install, where applicable, multifunction sensors to combine photoelectric light level detection, passive infrared levels, and ultrasonic motion detection. These sensors can be customized to increase artificial lighting levels based on motion detection or configured to perform different tasks based on the time of day.
- Program sensors to switch off or greatly reduce the lighting levels to address only specific tasks especially for periods of low occupancy.
- Employ motion detection sensors for ingress and egress paths connected to the BMS to provide specific illumination and reduce light pollution and energy consumption.
- Link the BMS to security systems, fire and life safety system and emergency management systems (EMS) to alert direct-response authorities in case of emergency situations.
- Consider the adaptability of the BMS, including what equipment can be controlled and how easy it is to reprogram the system.

FURTHER RESOURCES

Websites:

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8.6 [MO.6] TRANSPORTATION SYSTEMS IN BUILDING

8.6.1 APPLICABILITY

COMMERCIAL | EDUCATION | HOMES | HOSPITALITY | LIGHT INDUSTRY | MOSQUES | OFFICES | RESIDENTIAL

8.6.2 PURPOSE

To provide an effective automated means of travel for occupants and users between floors and spaces in the development.

8.6.3 CONTEXT

An effective mechanical or automatized transportation in the building is important for occupant's wellbeing, efficiency and productivity. The transportation systems such as elevators or lifts, escalators, moving pathways help all building users move horizontally or vertically from one place to another place in building. The means of transportation in a building change according to several factors which need to be considered when selecting any mechanical equipment used for vertical circulation in buildings, including, but not limited to the shape and size of the building, number of people, purpose of building, distribution of occupants and type of occupants e.g. children, the elderly or less able-bodied, in addition to traffic behaviour and occupancy loads.

Elevators, installed to cover vertical distance, have the advantage of minimum waiting and travel time if smartly designed. They provide desirable speed or acceleration, comfort of travel, automatic levelling at destination points and smooth embarkment or disembarkment. Elevators are most suitable for safety of privileged class such as older people, pregnant women or disabled people. Elevators can be installed in all types of buildings.

Moving walkways and escalators, ideal to cover horizontal or inclined distance in horizontal or vertical spaces of buildings, help moving people at good speed on continuous basis. They facilitate to adjust the speed of movement as people in hurry can walk or climb stairs faster on escalators or walkways. Moving walkways or escalators can be found in buildings such as, airports and train/metro stations, shopping centres, and exhibition auditoriums. Moving walkways help moving heavy luggage quickly and effectively. One of the unique applications of moving walkways is their installation facilitates to channel visitors at museums or zoos safely to pass through venue in a certain sequence. The speed of walkway should be designed for safety at exit and entry points and therefore should be in the range of 30 to 40 meters/ minute.

8.6.4 GUIDELINES

- Assess the passenger traffic demand and analyze passenger traffic flows to specify appropriate numbers of vertical and horizontal transportation, their type, capacity and speed.
- Assess the building functionality, form and layout arrangements to ensure the incorporation of these parameters into the design of the proposed transportation systems.
- Use, if necessary, simulation software to determine the design requirements of the transportation systems.
- Ensure the design of the transportation systems follows the recognized codes and standards applicable to the region, building typology, uses and user requirements.
- Provide vertical and horizontal transportation to meet the requirements of handling capacity and robustness in terms of for example: number of lifts, size, speed, waiting time, response time depending on the expected usage and building type.
- Optimize the design of the systems and ensure an adequate zoning arrangement.
- Design elevators to meet the requirements for use by persons with disabilities.
- Ensure proper control and energy management of equipment.
- Consider green elevators control strategies for operations, such as: reducing number of stops and selecting effective parking policies.
- Install an energy efficient recovery system in the elevator which is used in emergency situations to be able to reach the nearest story and be able to open the door.

FURTHER RESOURCES

Websites:

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TERMS AND ABBREVIATIONS

A	
ADPI	Air Diffusion Performance Index
ADT	Average Daily Trips
ASHRAE	The American Society of Heating, Refrigerating, and Air-Conditioning Engineers

B	
BOQ	Bill of Quantities

C	
Carcinogenic	Material substances agents with properties known to promote cancer.
CDA	Conformance to Design Audit
CDA stage	The stage of GSAS certification for obtaining the final certificate.
CIBSE	Chartered Institution of Building Services Engineers
Criterion level	The established level of the assessed criterion for meeting the requirement of Level (-1), (0), (1), (2), or (3).

D	
Development	The real estate development or the site development or the building project.
DGI	Daylight Glare Index
DNL	Day-Night Sound Level

E	
Eco-labeling	Labeling of products and materials with enhanced environmental, health, and resources conservation attributes.
ETS	Environmental Tobacco Smoke

G	
GORD	Gulf Organisation for Research & Development
Green transportation	Mode of transportation that does not rely on fossil fuel.
GSAS	Global Sustainability Assessment System

GSAS commissioning plan	In systems commissioning, it means a comprehensive document that outlines the commissioning process and the facilities to be commissioned.
GSAS-CM	GSAS Construction Management

I	
IESNA	Illuminating Engineering Society of North America
Illuminance	The measure of the amount of light received on a surface.
Indicator	(X), (Y), and (Z) in the criterion level.
Indicator result	The values of (X), (Y), and (Z) indicators.

L	
Light trespass	Obtrusive light which causes annoyance, discomfort, distraction, or a reduction in visibility.
LOC	Letter of Conformance
LOC stage	The stage of GSAS certification for obtaining the LOC.

M	
MDS	Material Data Sheet
MEP	Mechanical, Electrical, and Plumbing
MEPF	Mechanical, Electrical, Plumbing, and Fire Protection

P	
PMV	Predicted Mean Vote
Project, the	The project stakeholders including client, design team and consultants.

R	
Reflectance	The ratio of the amount of light reflected by a surface over the total amount of light incident on the surface.

S	
Sustainable approach	In facility management plan, it means there is a comprehensive model followed for strategic planning.
Sustainable parking spaces	In eco-parking, it means parking types are designed and built with sustainable techniques.

Sustainable techniques	In eco-parking, it means techniques that mitigate the negative impacts of heat island effect, rainwater runoff, and other open hardscapes with no shadings
T	
TAB	Testing, Adjusting and Balancing
T&C	Testing and Commissioning
Transmittance	The ratio of the amount of light passing through the surface over the total amount of light incident on the surface.
U	
ULE	Upward Light Emission
V	
VOC	Volatile Organic Compound

Building Sustainably

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