ICAO

ENVIRONMENT

# The Eco Design of Airport Buildings

**ECO AIRPORT TOOLKIT**

**The Eco-Design of Airport Buildings**



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## 1) Introduction

This e-publication is an overview of the environmental aspects related to airport buildings. Eco-design of airport buildings refers to considerations of green buildings and the environmental and resource-efficient operation and management of the airport building from a life-cycle perspective. This includes the overall process of airport planning, design, construction, operation, maintenance, refurbishment, and demolition. Since the airport is a complex hub for various facilities (shops, food outlets, air carrier operations) eco-design of airport buildings therefore entails complex collaboration among airport stakeholders, with an overall aim to minimize impact to the natural environment and human health. Planning and designing an existing or new airport building should take into consideration passenger and flight forecasts, since these buildings are expected to last for decades and should accommodate the expected growth. Recently, due to climate change, another relevant aspect to consider is future climate conditions and the airport buildings' resilience over the long term.

When siting and designing aerodrome buildings the safety and operational aspects are primary considerations. This publication is focused on environmental aspects of the design, planning and construction of airport buildings. The International Civil Aviation Organization (ICAO) has specific standards and guidance material which deal with other aspects and they should be consulted accordingly. Additionally, airport building design needs to consider the overall functionality of the airport system. Overall airport operations are dependent on aircraft connectivity and redundancy of systems. Terminal shape and layout should be designed to provide access for aircraft, and to facilitate the aircraft's access to taxiways and runways. However, there are many issues of environment and sustainability to consider when planning airport buildings. Airport sustainability combines economic, environmental, and social considerations into planning, design, construction, operations, and maintenance. The approach is often called EONS because it integrates economic considerations, operational efficiency, natural resources considerations, and social responsibility. ACRP Synthesis 10, *Airport Sustainability Practices* includes a list of sustainability focus areas and corresponding practices.

### Resources for Airport Building Design

There are many resources available on general airport and terminal design, such as ICAO's Annex 14, Airport Planning Manual (Doc 9184), Airport Services Manual (Doc 9137)[2], and Aerodrome Design Manual (Doc 9157). However, there are relatively few sources specific to environmental components of airport buildings. Guidance from the U.S. Federal Aviation Administration discusses the advantages of certain styles of concourses and gates in relation to runways and taxiways. Other sources focus on building materials and systems, such as:

- Airport Cooperative Research Program (ACRP) Report 25, Airport Passenger Terminal Planning and Design, Volumes 1 and 2;
- International Air Transport Association (IATA) Airport Development Reference Manual;
- ACRP Report 55, Passenger Level of Service and Spatial Planning for Airport Terminals; and
- ACRP Report 10, Innovations for Airport Terminal Facilities.

### Airport Buildings

Airport buildings take many forms, ranging from terminals for passenger use to hangars for aircraft to office space for administration. All can have an impact on the environment in their construction as well as

[2] Airport Services Manual – especially Part 9, and elements of Parts 6 and 1.

operational aspects. There are numerous environmental considerations with regard to building design and construction. For airports, there are also many operational elements that can be designed and managed to enhance the overall environmental performance of the facility.

Buildings such as rental car facilities or hangars have specific functional considerations – e.g., aircraft maintenance – that strongly influence their design and use. They are not designed so much for human occupancy as they are to accommodate specific processes. Structures such as airport passenger terminal facilities are primarily for public use, but also have some functional considerations as well. A terminal is meant to get flyers to their gate and onto the airplane, but must also accommodate traveler considerations such as ticketing/check-in, security, and baggage handling. Most passenger terminals provide services as well, such as restaurants and shopping. These buildings have some flexibility in their design and layout, but must satisfy the traveler requirements and have considerations such as accommodating layover times for large volumes of people.

The design and use of space at an airport is both an art and a science. Every airport is distinct, and there is no 'one size fits all' solution to eco-design of airport buildings. In addition, the layout and use of space are interconnected concepts. It is equally as important to look at the overall airport layout for 'eco-design' elements as it is to focus on the structures themselves. This publication will stay limited, however, to some of the basic environmental considerations that should accompany airport building development, management, and modification. Considering the environment and minimizing environmental impacts can be worked into airport buildings at many levels.

**Terminals**

Terminal planning and design often begins with a planning process to identify the constraints of the existing terminal and set priorities for the new terminal project. A good assessment will answer questions about expected passenger volumes, needs of the tenants and concessions, and other expectations that will drive the design or renovation of a facility. Environmental objectives should also be added to the planning process. The terminal is generally the biggest and most complex facility at an airport, with the most energy needs. Airport planners and environmental analysts should identify environmental issues for the proposed terminal project so they can be included in the project scope and budget. Likewise, the new structure may require an environmental impact assessment of some kind.

**Other facilities**

There are other facilities at the airports, other than the terminals, where eco-design considerations may be incorporated. Buildings in the airport landside such as cargo facilities and parking facilities may be areas where sustainability consideration can be applied. On the other hand, for some facilities, especially on the airside of the airport, there are safety and operational guidelines that the design should adhere to, for example reliable energy supply to air navigation equipment. For those cases, such regulation may not allow much room for environmental consideration. This document will mainly address the eco-design of terminal buildings, as that is where there is the most opportunity to use good design principles to reduce environmental impacts. Nevertheless, the same considerations may be applied to other facilities in the airport. Some buildings on which eco-design could be used for both construction and operations to improve environmental performance may include, inter alia:

- Cargo terminal buildings and warehouses
- Air traffic control towers and back-up air traffic control centers
- Hangars and maintenance facilities
- Parking structures
- Offices buildings
- Fuel farms

- Fire stations and fire training areas

**2) Elements to consider when planning eco-design of airport buildings**

### Integrated systems

An airport terminal brings many functions into one place. A modern passenger terminal facility is a combination of numerous systems such as lighting, temperature control, and waste management that are integrated into a physical shelter to make it comfortable for human activities. Besides these basics, any proposed airport development should be safe and efficient, it should be reasonable for the size of the airport, and it must meet any national airport design standards. As this paper will emphasize, a terminal should also be sustainable, follow environmental policies, and be designed to facilitate other environmental requirements (such as those found in an EMS).

Below, individual considerations are discussed, but in a terminal building these systems all interact. For that reason, the items discussed below have a lot of overlap.

### Siting and Access

An efficient terminal layout will reduce physical distances between areas to the extent practicable, and include infrastructure to facilitate passenger movement between areas. Terminal siting should include minimizing taxi distances from the gate or stand to runways and taxiways to reduce fuel consumption and emissions of taxiing aircraft. This can also minimize noise impacts to surrounding communities. These siting considerations can also minimize fuel consumption, emissions and congestion for airport and tenant vehicles. There are even examples where the location of the terminal was designed to shield a nearby community from aircraft noise.

Minimizing motor vehicle transport to and from the terminal reduces fuel consumption, emissions, and traffic impacts. To the extent possible siting should strive for convenient intermodal transportation options for public transport to and from the terminal. Efficient mass transit options that are convenient to the local community should be integrated into terminal siting when possible. Easy transport between terminals is also a consideration.

The location or feasibility of a site also depends on environmental characteristics, such as the presence of wetlands or historic resources.

### Building Design and Characteristics

The design of airport buildings can vary greatly, but there are a few basic principles to keep in mind that can enhance the environmental component of design. Plan to incorporate local characteristics and environment into the building design. This might include aesthetics such as colors and textures in the structure’s appearance, but also shape and decoration. Airports are a destination, and to the extent the airport terminal expresses the characteristics and values of a destination, the better. In terms of layout, orient the building to take advantage of natural light and ventilation. Anything that will minimize energy needed to heat, cool, and light the structure will make it more efficient and sustainable in the long run. Large airports undergo rapid change, and some airports are now planning buildings with the potential to be converted to other uses. It may be prudent in the planning and design process to create a structure that is flexible, and can be outfitted for different purposes at a later date.

### Power Sources and Energy Conservation

Airport buildings may use numerous sources of energy, including electricity and various types of fuels. Energy generation often results in emissions, and all energy consumption has a cost. Energy efficiency should always be a goal of terminal design or reconstruction for financial and environmental reasons.[3] Hopefully the concept design is such that energy waste is minimized as much as possible. This includes such things as insulation and low-energy appliances, but may also include the design of spaces with regard to ventilation needs. Even plantings can help reduce energy needs. A 'green roof,' in which there are plants on the roof of the building, can substantially lower heat absorption and thereby reduce energy needs. Also, a green roof can reduce storm-water runoff and serves as sound abatement along the runway approaches.

The energy needs of most passenger terminals are met by purchasing electricity from a local utility. The utilities may offer different purchasing options, such as lower pricing at off-peak times, or an option to purchase clean power such as wind power. In addition, airports have many options for developing onsite renewable energy through solar and other technologies which can be integrated into structural design. For instance, airports have employed the concept of the solar wall, which is a wall of the terminal that faces the sun and is used to heat water, which is then circulated throughout the building.

Some airports are pursuing their own "microgrid," or airport energy generation system. An airport that generates its own power, especially through renewable methods, enhances its resilience from external power fluctuations. Such a system requires cost up front to develop, but increases energy security in the event of storms or other types of events that may affect the reliability of electricity supply.

Employing modern technology, many structures are designed to continually monitor energy use. Simple tools such as 'sub-metering,' allow the airport to identify, track and address areas of high energy use, and thus to correct inefficiencies. There are more elaborate systems as well. Computer controlled 'smart building technologies' with sensors and whole-building automation allow airport operators to monitor the building as a system, rather than focusing on individual energy-using devices.[4] These systems will automatically track energy uses and make adjustments, such as in temperature or lighting control, as needed.

## Heating, Ventilation, and Air Conditioning (HVAC)

Maintaining a suitable and uniform thermal environment in the terminal buildings is often among the most energy intensive activities.[5][4] Efforts to reduce energy use, and the associated emissions that come from it, will often focus on improving HVAC system efficiency. The choice of an appropriate temperature setpoint, maximum utilization of natural ventilation opportunities, usage of heating/cooling strategies, proper thermal insulation of the terminal building, and HVAC management systems based on a periodic planning may bring significant energy reduction. Advanced modelling and simulation for predictive control can also minimize the energy and cost of operating HVAC.[6] Airports have been eager to replace older boilers with newer systems that use natural gas or renewable energy, such as solar heating systems or geothermal heat/cooling systems. More information on HVAC systems and technologies can be found from a variety of sources, and it is a critical component of passenger terminal design.

## Aircraft Ground Energy Systems (AGES)

To reduce the consumption of fossil fuels and the emissions they generate, more and more airport functions are switching to electricity use. This includes terminal gates that cater to aircraft electricity and ventilation needs. Aircraft Ground Energy Systems (AGES) at the gate can provide both electricity to the

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[3] For example, see ICAO e-publication *Renewable Energy at Airports*.

[4] [3] FAA Advisory Circular 150/5360-13A, *Airport Terminal Planning*

[5] Akyüz et al (2017). Economic and environmental optimization of an airport terminal building's wall and roof insulation. Sustainability, 9(10), 1849.

[6] Ortega Alba et al (2016). Energy research in airports: A review. Energies, 9(5), 349.

aircraft and pre-conditioned air to heat or cool the aircraft. This replaces the use of the aircraft's auxiliary power units (APUs). Fixed pre-conditioned air (PCA) units supply heated/cooled air to parked aircraft so that passengers are comfortable as they enplane and deplane. Ground power units provide power to aircraft for internal lighting and to ensure continuous power for the navigation systems. When employed together, the ground power units and PCA enable parked aircraft to forego the use of the their APUs, resulting in significant reductions in fuel consumption and associated air emissions. In addition, many airport ground support vehicles are now electric, and airports are building charging stations in or near terminals to recharge these vehicles.

**Emissions**

Aircraft are the largest source of emissions at an airport, but the terminal buildings have several relationships to emissions, and can also influence aircraft ground emissions. In terms of the structure itself, the materials used for the terminal building can be selected strategically to minimize Greenhouse Gases (GHG) and other emissions. Use of recycled materials usually reduces the overall carbon footprint of building materials. As discussed above, the energy load that the building requires to operate, and the sources of energy, have links to emissions. A terminal designed with PCA and ground power for the aircraft can see significant reductions in airfield emissions. Finally, the siting and design of the building can be done to reduce emissions, for example minimizing the aircraft taxi distance from gate to runway. All of these factors, the building materials, the operation of the terminal, and how readily the terminal facilitates efficient airfield operations, all affect local air quality and atmospheric concentrations of Greenhouse Gases (GHG).

**Waste Management**

Passenger terminals must be designed for materials to come in, and waste to go out. Planning for efficient waste management, such as through recycling or other processes, is a key way to reduce environmental impacts. Airport operators should have a goal to maximize recycling, reuse, and waste reduction in boththeir terminal construction as well as its operation. More information on waste management can be found in the accompanying Eco Airport Toolkit paper on *Waste Management at Airports*.

**Water Management and Conservation**

Water considerations for an airport include availability of potable water for use within the facility; it also means effective management of surface stormwater runoff, containment ponds, and other infrastructure designed to mitigate impacts of the airport on local water resources. Management of water systems has implications for building design, and many of these considerations are specific to a region. A coastal airport will have different considerations for managing surface water than an inland one. Some airports have essentially unlimited access to inexpensive potable water, while others don't. Airports in water-constrained areas have started applying interesting techniques for water efficiency and conservation. For example, restrooms can be designed with low-flow fixtures to conserve water use, and sensors that automatically shut-off water faucets when not in use. Other examples include using 'gray water' or water reclaimed from other uses such as rainwater runoff. Gray water isn't safe for consumption but can be used for other purposes such as restrooms or landscaping.[7] Airport landscaping often uses water, but this too can be designed to minimize water needs. For more information on water use by airports see ACRP Report 154 (2016) *Water Efficiency Management Strategies for Airports*.[8]

[7] The term "grey water" could refer to domestic wastewater generated from less polluted sources, such as kitchen sinks, washing machines, dishwashers, hand-washing basins and showers, as described in UNDP 2013 document – Water Governance in the Arab Region.

[8] Available at: http://www.trb.org/Publications/Blurbs/174444.aspx

**Circular Economy Considerations for Terminals**

The circular economy provides an holistic approach on developing new economic business models (e.g. product-service systems) where the value of assets (e.g. terminal buildings) and services is maintained as high as possible. The circular economy involves all stages of a terminal development (design, construction, and operation). Terminal buildings should be designed for reuse, disassembly, refurbishment, and/or recycling. Airport operators should have a goal to minimise use of virgin materials and increase the opportunities for value creation in both their terminal construction as well as its operation. More information on circular economy business models can be found in the accompanying Eco airport Toolkit paper on *Waste Management at Airports*.

## 3) Sustainability Rating Systems and Airport Buildings

A wide array of sustainability rating systems has been developed in the past two decades to encourage and facilitate sustainable building and infrastructure practice. Although these systems were developed with varying purposes and features, they may be used as a technical reference point for guidance and metrics to define and evaluate the progress towards sustainable performance of airport buildings, even when airports do not pursue a formal rating or certification.[9] Some of the benefit of sustainable rating systems may include:

- Quality assurance
- Environmental stewardship
- Assurance of long-term viability
- Basis of financial incentives
- Increased accountability and public recognition

The systems listed in the following section are a sample of some of the largely accepted and widely used certification systems currently available on the market that may be applicable to or already used by airport operators. This list is not exhaustive, and ICAO does not endorse any specific system. They are provided here to give some examples of systems that could be used for the eco-design of airport buildings. In addition to the systems mentioned in this e-publication, there are national systems that have been identified, some in the attached Case Studies, such as BOMA Canada, Estidama (UAE) and Dutch Energy Performance Certificate. All the certifications below are based on rating scales, performance categories, measurement systems, and other scores. A brief comparison between the systems with respect to target project and project phases is given below[10]:

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[9] Note that these building certification systems are not related to the airport operational or safety certifications.

[10] Amended according to the Task Group interpretation from HDR's analysis and Bernardi et al (2017) "An analysis of the most adopted rating systems for assessing the environmental impact of buildings." Sustainability 9.7 (2017): 1226; HDR: https://www.hdrinc.com/sites/default/files/inline-files/rating-systems-help-achieve-sustainability-goals-comparison.pdf

| | Intended For | | | | | | | Project Phase | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | New Building | Existing Building | Renovations | Interior | New Infrastructure | Existing Infrastructure | Communities / Neighborhoods | Planning | Design | Construction | Operation & Maintenance |
| LEED | | | | | | | LEED ND | | | | |
| BREEAM | | | | | | | | | | | |
| HQE | | | | | | | | | | | |
| DGNB | | | | | | | | | | | |
| ENVISION | | | | | | | | | | In Development | In Development |
| BOMA 360 | | | | | | | | | | | |
| SITES | | | | | | | | | | | |
| Parksmart | Parking Facilities | Parking Facilities | | | | | | | | | |

*Figure 1. Comparison between the certification systems*

**LEED (Leadership in Energy and Environmental Design)**
With more than 94,000 projects in over 165 countries and territories, LEED is the most widely recognized green building certification system in the world.[11] Developed by the US Green Building Council, LEED provides a framework for practical and quantifiable methods for healthy, efficient, and cost-effective green building design, construction, operation and maintenance practice. Based on the project type, LEED is divided into sub-categories of: Building Design and Construction (BD+C); Interior Design and Construction (ID+C); Building Operations and Maintenance (O+M); Neighborhood Development (ND); Homes; and Cities and Communities.

For all the above types, the current version 4 of LEED certification is structured in four-tier award systems to measure progress of achieving high performance in 6 key areas:

- Location and Transport
- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality

[11] https://new.usgbc.org/leed (Accessed on 27/09/2018)


*Figure 2. LEED Building Certificate by performance*

**BREEAM**

BREEAM (Building Research Establishment Environmental Assessment Method) was first introduced by the UK Building Research Establishment (BRE) in 1990. It is the world's longest serving system with more than 565,000 certified projects issued in more than 70 countries.[12] BREEAM is the most widely used certification system in Europe, and is composed of ten categories as follows through 71 criteria, with a percentage-weighting factor being assigned to each category:

- Management
- Health & well-being
- Energy
- Transport
- Water
- Materials
- Waste
- Land Use & Ecology
- Pollution
- Innovation

The overall score obtained from the points earned will determine the level of BREEAM certification, or number of stars - from one-star 'Pass' to five-star 'Outstanding' level.

[12] https://www.breeam.com/ (Accessed on 27/09/2018)

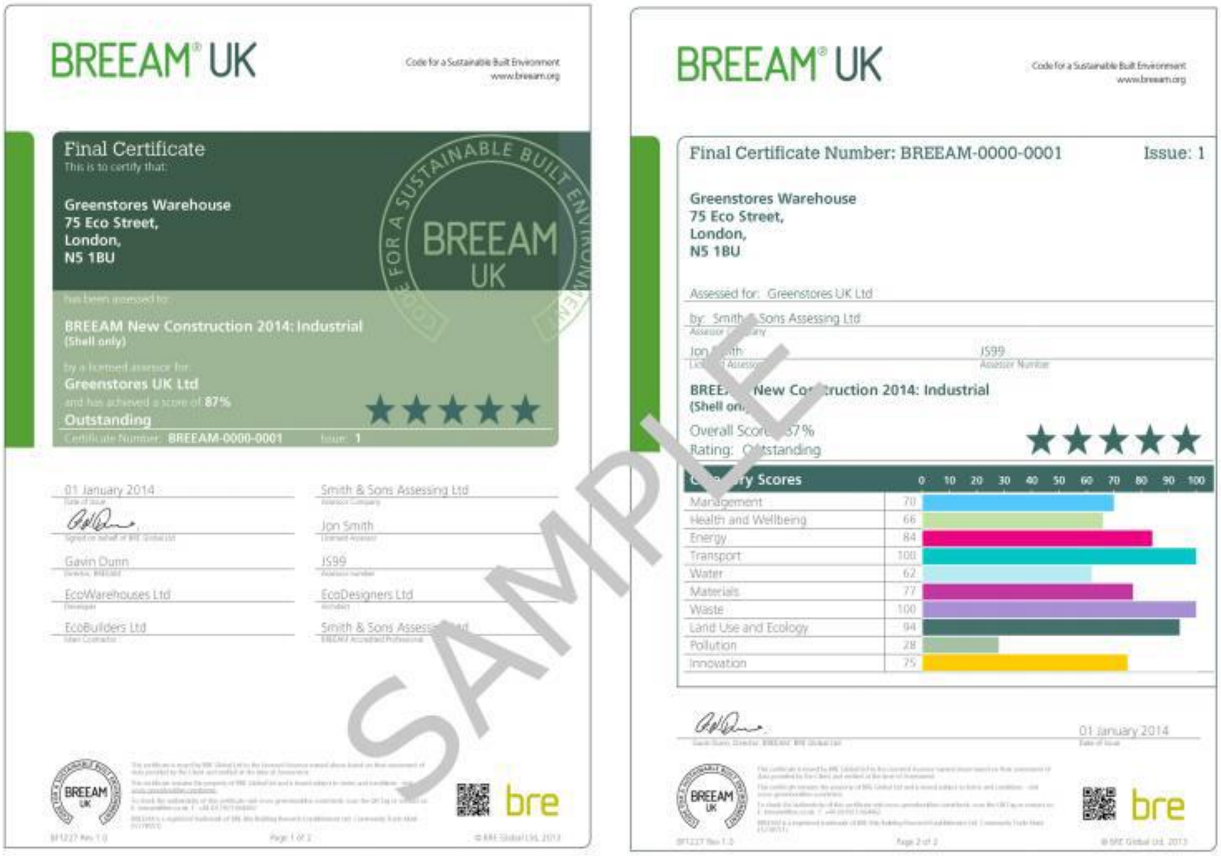


*Figure 3. Example of BREEAM certificate post construction*

**HQE**

Haute Qualité Environnementale (HQE) certification, developed in 1994 by the namesake association of France, is the second oldest certification scheme for sustainable buildings. HQE dominates the European certification market by surface area, although it is highly concentrated in France.[13]The performance requirements are systemized into four topics – environment; energy and savings; comfort; and health and safety – which amount to the total of 14 targets. Unlike the other certification systems, there is no weighting in HQE by category. The performance at each target is assessed to determine performance by topic, then is aggregated for overall level – also expressed as the number of stars.[14]

**DGNB**

Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB) certification was launched in 2009 by the namesake German Sustainable Building Council. DGNB assesses performance in a 6 category system, covering all the fundamental aspects of sustainable building – encompassing ecology; economy; sociocultural and functional aspects; technology; processes; and site. The first three quality sections have equal weight in the assessment (version 2018), hence making DGNB the only sustainability rating system that places equal importance on both the economic aspect and the ecological aspect of sustainable building. It should also be noted that DGNB uses Environmental Product Declaration (EPD) as the data

[13] 12 GBC France, "International environmental certifications for the design and construction of non-residential buildings – position of HQE relative to BREEAM and LEED" (2015)

[14] https://plgbc.org.pl/wp-content/uploads/2015/07/2015_EN_France_GBC_study_HQE_LEED_BREEAM.pdf

basis as prescribed in ISO 14025 and BS EN 15804, and employs quantitative assessment of data over the entire life cycle of the building or urban district.

**Envision**

Compared to the other systems that have been discussed above, the Envision rating system is designed to work with large civil infrastructure projects rather than specifically focusing on building structures. Developed by the Institute for Sustainable Infrastructure (ISI) in the United States, this system is primarily designed for the US and Canada, although the benefits and criteria can be adapted to other geographies. The rating system is divided into five categories – quality of life, leadership, resource allocation, natural world and climate and risk – totaling 60 performance objectives to be scored. Based on the objectives scored, four levels of rating are given from Bronze to Platinum.

**Parksmart**

Parksmart can be useful for airports looking for eco design of their parking buildings. Parksmart (formerly Green Garage Certification) is a certification focused on sustainable parking structure design and operation. It provides alternatives to reduce operational costs, increase energy efficiency and improve lighting and ventilation at parking infrastructure.[15]

Parksmart certification can be used for existing or new parking facilities of all types, including a standalone project or a mixed-use building of all sorts: commercial, university, municipal, hospital, retail and hospitality.[16] Some of the elements that could be incorporated into a parking infrastructure design are electric vehicle charging, stormwater management, cellphone lot for car drivers to reduce idling and congestion, use of alternative fuel utility vehicles for parking operations, car wash water reclamation, among others.[17]

## 4) Conclusions

This e-publication has provided a high-level overview of relevant considerations for eco-design of airport buildings. There are many opportunities to incorporate environmental elements into airport planning, design, construction, operation, maintenance, refurbishment, and demolition. This paper only includes the primary considerations that airports have used and may be worthwhile incorporating. The sustainability rating systems included in this document may also be used as a reference or as guiding principles, through which a project can strive to meet high standards while minimizing environmental impacts. Airports are encouraged to use this toolkit in their effort to develop infrastructure that will be sustainable and functional for the airport for years into the future.

[15] Parksmart Online. Available at: http://parksmart.gbci.org/about
[16] Parksmart Online. Available at: http://parksmart.gbci.org/about
[17] Fort Lauderdale-Hollywood International Airport - Palm Garage. Available Online: http://parksmart.gbci.org/fort-lauderdale-hollywood-international-airport-palm-garage

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International Air Transport Association (2014), *Airport Development Reference Manual*

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