ACI Asia-Pacific

Green Airports Recognition 2019

Green Airport Infrastructure

Disclaimer

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ACI Asia-Pacific

June 2019

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Introduction and Acknowledgements

The Green Airports Recognition was established with the support of the ACI Asia-Pacific Regional Environment Committee to promote environmental best practices that minimize aviation's impact on the environment and to recognize the region's airport members who have outstanding accomplishments in their environmental projects.

To promote the best implementation of the environmental management frameworks and programmes in the aviation sector, **Green Airport Infrastructure** was chosen as the theme for this year's recognition. Nineteen eligible submissions were received from member airports, representing 17% of the total passenger traffic in Asia-Pacific and the Middle East region, 18 of whom are already accredited under the *Airport Carbon Accreditation* program, with 4 airports being carbon neutral. Apart from the green building certified airports, a number of member airports also demonstrated their efforts in reducing the environmental impacts and creating positive benefits through their green infrastructure projects.

Our airport members' efforts demonstrated in their submissions are recognized and consistent with the recommendations and endeavours of other international bodies.

According to the World Green Building Council Annual Report 2017/2018, 2.65 billion m^2 of green building space are certified around the world. It is estimated over 2 million m^2 of these certified green spaces are airport infrastructure from Asia-Pacific Region. This shows that our airport members are already striving for better ways to improve passengers' traveling experience and enhance the sustainable performance at airports. Airports certified under recognized green building system were encouraged to share their stories with the airport community as part of this year's Green Airports Recognition.

Our airport members' efforts are also consistent with the United Nations, who in 2015 established 17 Sustainable Development Goals (SDGs) to promote a more sustainable development around the world and one of the SDGs is to call for action by all countries to invest in its infrastructure, sustainable industrial development and technology. To develop quality, reliable, sustainable and resilient infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all is the key to achieve the environmental objectives.

The Airports Council International's (ACI) Policy Handbook also provided the overview of how systematic environmental management system and framework could define, assess and ensure implementation of environmental mitigation measures for airport infrastructures. "A range of standards and recognition frameworks are in place to support environmental management. This includes ISO 14001 (Environmental Management System) or EMAS (Environmental Management Audit Scheme) and others. More specific frameworks include ISO 50001 (Energy Management) or building performance certifications such as LEED, BREEAM and DGNB."

The design, construction or operation of the airport members' submitted green infrastructure projects have all demonstrated achievements in supporting the economic development, increasing the efficiency of resource consumption, adopting clean and environmentally friendly technology and empowering the communities.

The submissions were reviewed by a panel of judges comprising:

- Mr. Christopher Paling, Senior Lecturer in Environmental Management, Manchester Metropolitan University
- Mr. Christopher Surgenor, Editor/Publisher, GreenAir Online
- Ms. Juliana Scavuzzi, Senior Manager, Environment, ACI World
- Dr. Panagiotis Karamanos, Aviation Environmental Consultant
- Ms. Patti Chau, Regional Director, ACI Asia- Pacific

We would like thank all judges for their expertise and valuable time.

After collective assessment with eight relevant criteria, recognitions were given by the panel of judges to the following airports:

Over 45 million passengers per annum:
- Platinum – Indira Gandhi International Airport
- Gold – Chhatrapati Shivaji Maharaj International Airport
- Silver – Hong Kong International Airport

Between 10 to 45 million passengers per annum:
- Platinum – Taoyuan International Airport
- Gold – Sydney Airport
- Silver – Rajiv Gandhi International Airport

Less than 10 million passengers per annum:
- Platinum – Adelaide Airport
- Gold – Al Bateen Executive Airport
- Silver – Nadi International Airport

The outstanding work of the above 9 airports plus other airports submissions are summarized in this publication to promote best practice sharing.

It should be emphasized that all the airports in this publication deserve to be recognized because of their commitment to Green Airport Infrastructure and willingness to share their stories with the airport community, fully reflecting the objective of this Recognition.

Acknowledgement of All Recognized Airports 2019

Section 1: Green Building Design

Al Bateen Executive Airport
Al Bateen VVIP Terminal

The VVIP Terminal is a private lounge setup as a separate building located within Al Bateen Executive Airport (EBEA) in Abu Dhabi. It was constructed as part of EBEA development program, assigned with highest priority on a fast-track approach, and was completed in July 2016.

This unique terminal building of 2200 m² of GFA provides the necessary exclusive facilities to support the needs of Heads of States and VIPs while they travel to and from the EBEA.

In addition to its distinctive nature, this project was designed to minimize environmental impacts and to reduce demand for resources; as a result, it was awarded Estidama 3 Pearl certification under the UAE- Abu Dhabi green building rating program.

Comprehensive energy efficiency technologies were integrated in a whole building system approach in order to create an “intelligent green building” reducing its energy demand by 60.2% compared to a baseline (ASHRAE 90.1:2007), with 32.5% from a Photovoltaic system that is fully integrated into the building design as a second roof structure further reducing the building solar heat gain as well as contributing to its overall energy performance.

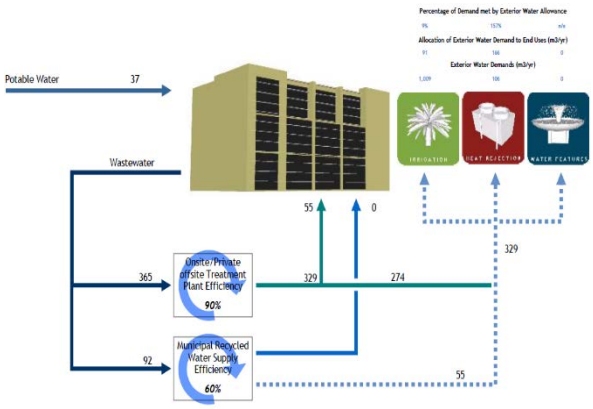
Efficient water fixtures as well as a system for the collection of condensate water is also in place reducing the building overall water consumption by 61.9%, with 39.6% being collected from condensate drains and reused for irrigation and other uses.

Measures to ensure excellent indoor environment quality were carefully implemented to support healthy indoors and enhance occupants’ wellbeing, through a well thought through HVAC strategy and a greater degree of ventilation quality, and the use of natural daylight together with an appropriate artificial lighting creating a visually comfortable environment.

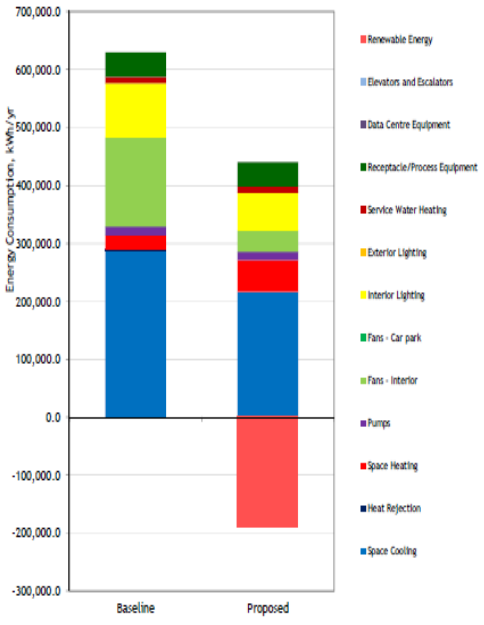
Building materials were specifically selected considering their “whole-of-life” cycle with an overall objective to improve the social and environmental outcomes associated with their manufacture, transport, installation and disposal.

Project Graphics

Landside view/PV panels on the roof



Water demand calculations



Energy demand modeling

Private Majlis

Green Building Design

Bahrain International Airport
Airport Modernization Programme

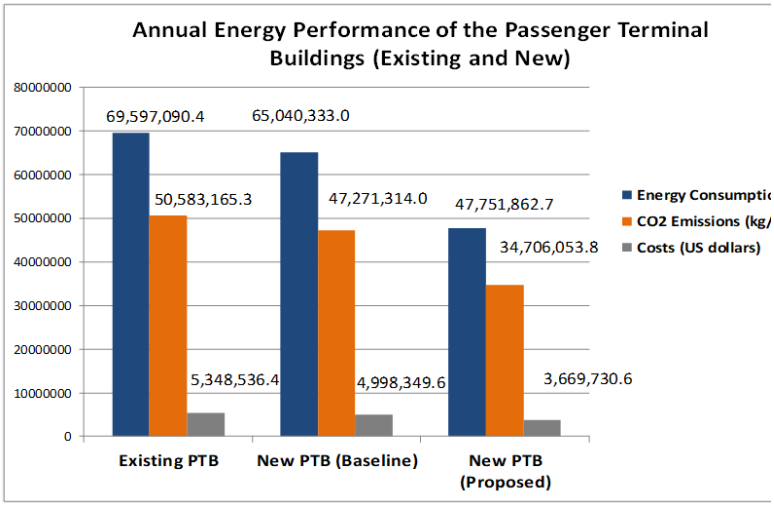
In line with growth of regional aviation sector, an inclusive project, known as Airport Modernization Programme (AMP) has been developed for Bahrain International Airport to be operational by third quarter of 2019. The main objective is to elevate the airport's infrastructure while increasing the capacity to 14 mpax. The AMP is comprised of development of a new Passenger Terminal Building (PTB), Central Utility Complex (CUC) supplying district cooling, treated water, and other services to serve the project needs; multistory car park (MCP) and upgrading 17 stands to be equipped with underground Ground Support Equipment (Pre-Conditioned Air, 400Hz, and fuel hydrant) to reduce noise and improve ambient air-quality.

The PTB is targeting LEED Gold certification aiming at minimizing the ecological impact. PTB will reduce more than 25% of energy usage comparing to a conventional PTB elsewhere in the industry. Operational cost saving from reduced energy demand on the PTB will reach up to 1.3 million USD annually. Projections of savings are based on the IES (Integrated Environmental Solutions) Energy Model calibrated by on-site testing of installed systems and building air-tightness.

Energy demand of buildings in Bahrain is dominated by air-conditioning systems. Although the built up area of the new PTB will be four times the size of the existing, the new PTB will achieve energy savings of 30% comparing to the existing PTB energy performance. Energy reductions will be achieved via sustainable design of the building envelope, in which low heat transmittance is attained for all materials, eliminating potential thermal bridges. Other implemented strategies include integration of a comprehensive shading scheme suitable for all seasons and façade orientations, efficient cooling system that will lead to 23% of energy recovery; and Building Management System (BMS) that will control the installed equipment according to fluctuating demand of systems like HVAC and artificial lighting.

Project Graphics

Existing and New Passenger Terminal Buildings built up areas and targeted LEED certification for the AMP.



Comparison chart of energy consumption, cost, and CO2 emissions of the existing Passenger Terminal Building and the New Passenger Terminal Building Baseline Energy Model (based on ASHRAE 90.1 2007) and Proposed Energy Model (based on current construction) using IES.

New Passenger Terminal Building Construction Site.

South façade of new Passenger Terminal Building Model.

Green Building Design

Changi Airport Group
Environmentally-friendly Changi Airport Terminal 4 Building

Terminal 4 has been designed from the ground-up to be environmentally-sustainable. Terminal 4's green design elements have enabled it to be awarded the Singapore Building and Construction Authority's Green Mark Gold Plus Certification.

Energy-efficient Lighting

T4 makes extensive use of natural lighting, with the skylights allowing natural light to infuse the terminal during the day, thereby reducing the need for artificial lights. A system of photocell sensors and dimmers are used to regulate the amount of artificial lighting at the arrival and departure level common areas and at the central galleria, so as to supplement sunlight in an efficient manner. Within the washrooms, a combination of motion sensors and dimmers serve to switch off unnecessary lighting when the space is not in use.

Innovative Baggage Handling System

The Baggage Handling System at Terminal 4 uses the Individual Carrier System for automatic sortation. This is the first time that Changi Airport has implemented such a system to sort originating bags. The system is made up of short conveyer belts, which only runs when a tray carrying a check-in bag passes through it. Each modular conveyer section will stop operating immediately after transferring the bag to the next section.

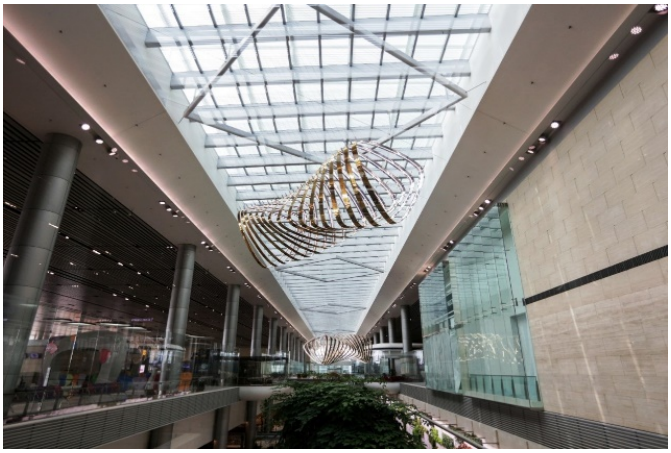
Energy Management System

The consumption of major engineering sub-systems in Terminal 4 is monitored by an energy management system which helps to record and trend electricity usage at 15-minute intervals. With improved visibility on how energy is distributed and used, there will be greater opportunities to optimise the operation of these larger systems.

Water-efficient features

Condensate water from the Air Handling Units is collected and recycled for irrigation purposes. This is sufficient to water all the landscaped areas within Terminal 4, which is no mean feat given that there are over 340 different species of plants and trees within the terminal.

Project Graphics



Use of Natural Lighting and Lighting Control

Building Management System optimises efficiencies of key systems

Motion sensors and dimmers switch off lighting when the space is not in use

T4 has been designed from the ground-up to incorporate green design elements

Green Building Design

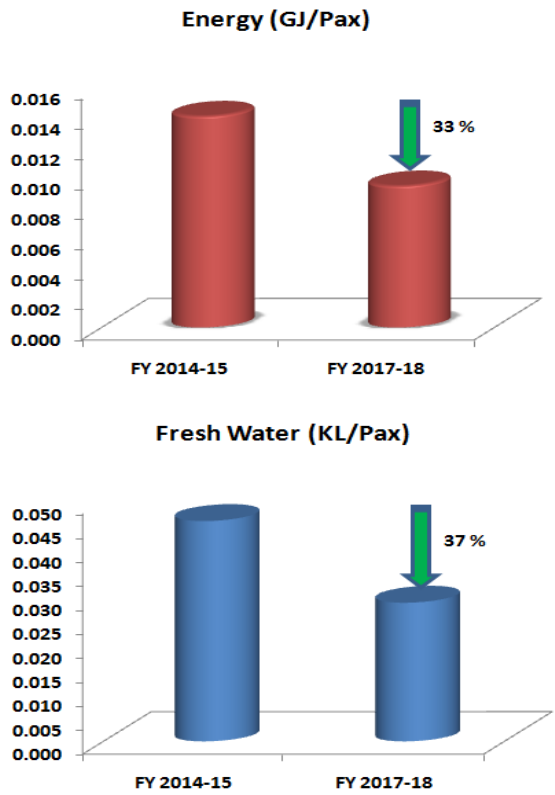
Chhatrapati Shivaji Maharaj International Airport
New Integrated Terminal 2

Mumbai International Airport Limited (MIAL) operating Chhatrapati Shivaji Maharaj International Airport (CSMIA), being a responsible corporate citizen has undertaken various measures towards safeguarding the environment and has put strenuous efforts to enhance operational excellence while confirming to highest standards of environment management. Sustainability being completely aligned in our DNA, our major showcase New Integrated Terminal 2 (T2), designed to replace the old Sahar International Terminal was not only to be a benchmark in architecture and design but also to be one of the greenest infrastructures in the country.

From the stage of planning & designing itself, MIAL management conceptualized T2 to have minimum environmental footprint with maximum customer focus. This was achieved by including state of the art green building technologies & features, external green building experts. At T2, MIAL ensured amalgamation of green and environmental features like Energy and water efficiency, Building management system, Waste reduction and management, Sustainable and local purchases, Use of green transportation, Use of Green chemicals, Use of natural light & Energy-efficient control of indoor environment (lighting and thermal comfort).

MIAL's efforts bore results with T2 being showered with several prestigious awards and accolades across categories. It achieved LEED Gold certification making it among the few airports in India and globally to be so. It has also achieved highest possible green building certification under IGBC green existing building program "Platinum" rating. All the environmental optimization features put in T2 helped MIAL to achieve ACI's *Airport Carbon Accreditation* Level 3+ "NEUTRALITY" highest airport accreditation in carbon management. Many other awards of National & International recognitions in the field of environment & customer satisfaction were awarded to MIAL due to Terminal 2 intervention. MIAL's T2 thus serves as a successful case study highlighting holistic success in all fields that can be achieved by organizations by going green.

Project Graphics



Energy & Water reduction achieved

MIAL T2 comparison with other Airports


CII
Confederation of Indian Industry

Indian Green Building Council (IGBC)

hereby certifies that

New Integrated Terminal 2 - Chhatrapati Shivaji International Airport
Mumbai

has successfully achieved the Green Building Standards required for the following level of certification under the Leadership in Energy and Environment Design (LEED) for India Green Building Rating System

LEED India for New Construction Gold
January 2014

C N Raghavendran	Dr Prem C Jain	S Raghupathy
Chairman, LEED India	Chairman, IGBC	Executive Director, CII-Godrej GBC

LEED “Gold” Certificate T2


CII
Confederation of Indian Industry

Indian Green Building Council (IGBC)

hereby certifies that

Mumbai International Airport Limited (Terminal-2)
Mumbai
(IGBC Registration No: GEB 15 0662)

has successfully achieved the Green Building Standards required for the following level of certification under the IGBC Green Existing Buildings O&M Rating System

IGBC Green Existing Building Platinum
September 2016
This certification is valid for the next 3 years

Gurmit Singh Arora	Dr Prem C Jain	K S Venkatagiri
Chairman, IGBC Green EB O&M Rating	Chairman, IGBC	Executive Director, CII-Godrej GBC

IGBC “Platinum” Certificate T2

Green Building Design

Hong Kong International Airport
Sustainable Midfield Concourse Development at Hong Kong International Airport

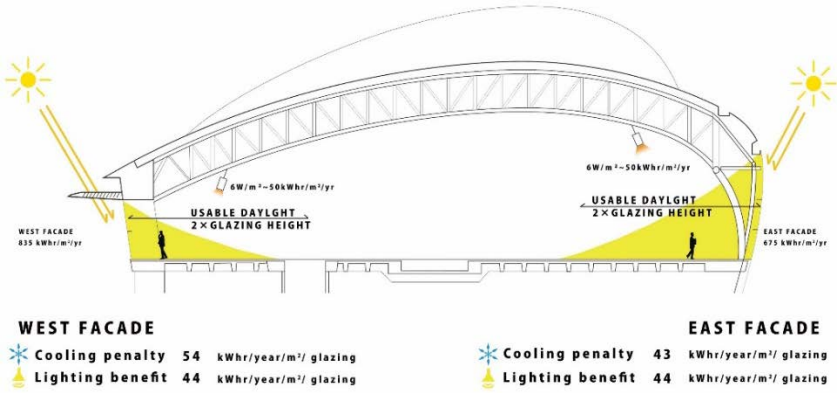
The Midfield Concourse (MFC) is one of the most important expansion projects completed in recent years at Hong Kong International Airport (HKIA). The 105,000m2, five-storey MFC commenced operation in December 2015. The MFC has increased HKIA's handling capacity by over 10 million passengers per year.

The MFC has been designed as an exemplar sustainable building that contributes to HKIA's "Greenest Airport" pledge. Overall, there are 35 key green initiatives that have been incorporated into the design of the MFC project.

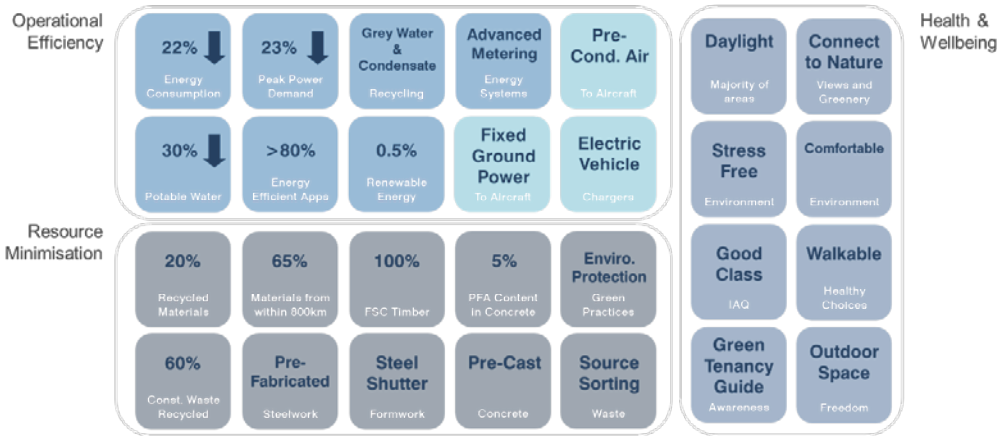
The MFC was designed to be oriented along the north-south axis, and adopted an environmentally responsive cross section. Taking into account lower annual solar heat gains on east-facing facades in Hong Kong, the east face of the MFC has a high expanse of glazing, which significantly increases daylight, while the west facade glazing is lower. Performance is enhanced by incorporating skylights on the roof that face due north. Intelligent daylight and occupancy controls work in parallel to further optimise performance, and a shading hierarchy was formulated to reduce solar heat gain, thereby lowering the cooling system's energy consumption. In addition, approximately 1,200 m2 of solar panels have been installed on the rooftop to supply sustainable electricity for the concourse, creating one of the largest systems of its kind in Hong Kong. The low-power-consumption lighting system features daylight sensors working in parallel to optimise performance and efficiency. The air-conditioning system uses recycled greywater and condensate water for its water-cooled chillers.

The MFC project demonstrates how the early consideration of sustainable design principles, and a systematic evaluation and prioritisation of the possible combinations of passive design strategies and low-energy active design techniques can help take forward innovative ideas and sustainable design initiatives through the different stages of a project's development to deliver an energy-efficient, high-performance building.

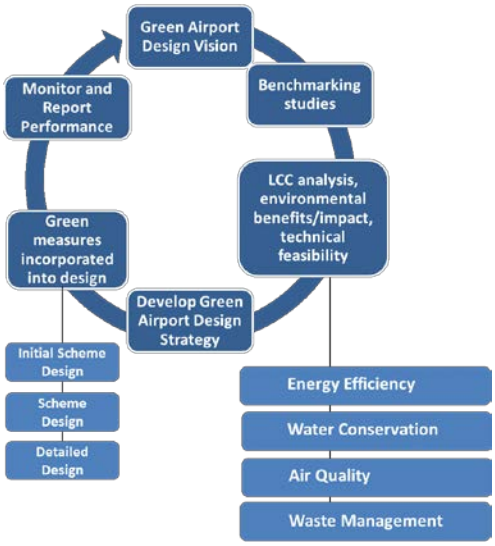
Project Graphics



Envelope Optimisation adopted at MFC design



MFC's Sustainability Performance



MFC's Green Design Process

East and West Facades and North-facing Skylights at MFC

Green Building Design

Indira Gandhi International Airport
Dynamic Green Infrastructure Platform – IGIA T3 by LEED ARC

DIAL has adopted various Green Airport Infrastructure program at Delhi Airport since its commencement. Our aim is "to operate the airport with care for environment and develop environment friendly green airport infrastructure for high performance operations of utilities, buildings and airport systems with minimum resource consumptions"

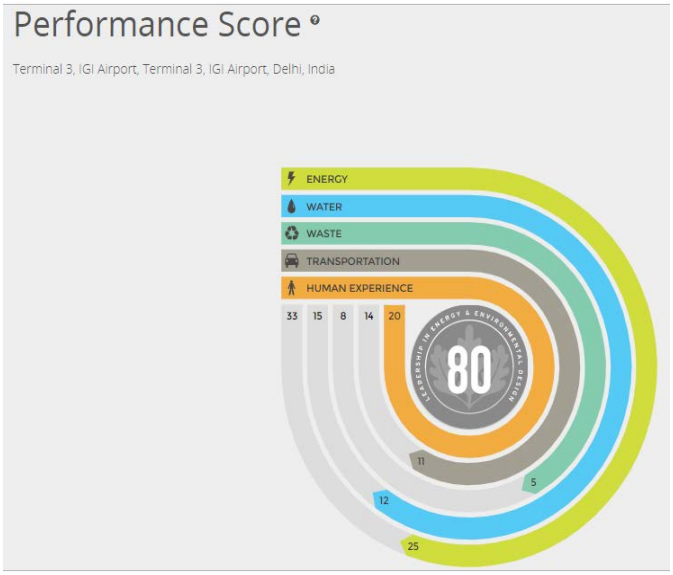
As part of modernization and restructuring IGI Airport, DIAL has developed state of the art Terminal 3 at IGIA, incorporating all the advanced technologies with key focus on building "Green Airport Infrastructure" complying with globally recognized "LEED" Standards. This raised IGIA T3 to become the first airport in the world to have a certified green footprint of 0.55 million m2 in 2011 as "LEED- New Construction Gold". This also helped Delhi Airport in getting other global reorganizations for superior service quality (ACI's World No. 1 Airport), resource efficiency, sustainability etc. including the 1st Carbon Neutral Airport in Asia Pacific region as per ACI's *Airport Carbon Accreditation* program.

Further during operation, DIAL integrated the requirements of green existing building guidelines, which further raised the airport building performance in resource consumption, customer service and wellness etc. This resulted in "Existing Building Platinum" certification from IGBC in 2016.

We believe that the efficient design does not guarantee existing operation's sustainable performance! This gave us an opportunity to explore the advanced performance based online monitoring and building scoring platform "LEED ARC" for T3. "LEED ARC" provides annual LEED recertification and global benchmarking of buildings with similar type. The plaque of ARC displays a score, which reflects the measured performance of the building across five categories: energy, water, waste, transportation and human experience.

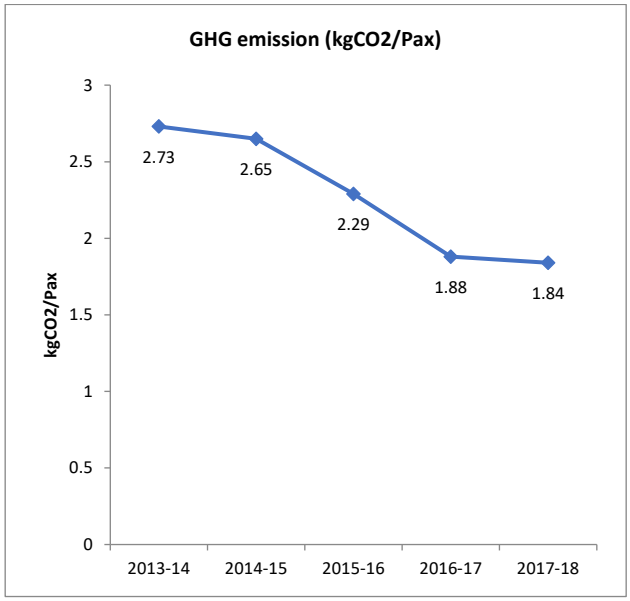
DIAL adopted LEED ARC in the year 2016 and got certified at Platinum Level in 2018 as globally first for achieving global benchmark values in all the 5 categories and it helped in reducing environmental footprints at IGIA.

Project Graphics



https://app.arconline.io/plaque/1000098896/zSejmxjXmimc4Nq7vVDkf0na

Arc performance Score of Terminal 3, IGI Airport, Terminal 3, IGI Airport, Delhi, India



33% reduction in GHG emission

GHG emission (kgCO2/Pax) of DIAL

Delhi Airport's Green Infrastructure Journey from LEED Gold in 2011, to IGBC Platinum in 2016 and LEED ARC - 2018

DIAL has developed ICAO approved 5-day STP program on Green Infrastructure and is imparting training to Aviation Stakeholders

Green Building Design

Nadi International Airport
Nadi Airport Terminal Modernization Project

The $129million newly renovated Nadi International Airport Terminal was officially opened on the 4th of June 2018 by the Honourable Prime Minister of Fiji, Mr. Voreqe Bainimarama.

The project is of significant importance to the nation as it reflects our commitment to offer the travelling public with world class facilities and services.

The Terminal is certainly the biggest and most modern airport terminal in the Pacific islands and one worthy of Fiji's status as hub of the Pacific.

The project included significant structural changes, a complete makeover of the facility, covering a floor area of 28,000m², which includes retail spaces, lounges, airline gates, public facilities, office space, and back-of-house areas. A new chilled water system and an energy efficient building management system with monitoring systems have been installed.

The project also include a new car park facilities, a two-lane departures passenger drop-off area with extended high roofing, a bigger, high-ceilinged departures terminal, self-check-in kiosks, an expanded departures immigration area with additional counters, a brand-new departures lounge with world-class duty-free shopping, a kids' play area, a prayer room, a smoking lounge, brand new airline lounges and an expanded arrivals landing area with additional immigration counters and carousel.

Lightings in the renovated areas were replaced with LED lights. The emergency backup systems were upgraded with new and more efficient generators and the security access control systems across the terminal were upgraded to meet the IATA and ICAO requirements. The upgraded terminal features a modern design and a sleek appearance with better provision for natural light and air. It includes a new departure check in hall with a 7m high raised ceiling and new check in desks bringing the total number to 36.

The project started in August 2014 and took two years and eight months to complete.

Project Graphics

High Roof International Check-in with glass wall fittings.

Pyramid Roofing Structure at the International Departure Hall.

Replacement of all lightings with LED lights and is managed through the BMS.

Flower Garden at the front of the Terminal Building.

Green Building Design

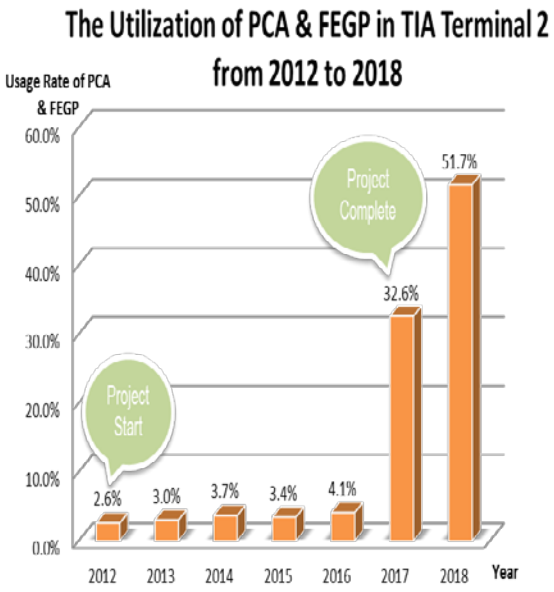
Taoyuan International Airport
Air bridges, PCA, and FEGP Retrofit Construction in Terminal 1&2

Considering the obsolete specification of air bridges and relevant equipment, Taoyuan International Airport Corporation Ltd. (TIAC) encountered with low satisfaction and low utilization rate on airside infrastructure before 2012. In order to enhance the applicability of airside infrastructure, reduce auxiliary power unit (APU) and ground power unit (GPU) use, clean up the crowed apron area, and improve air and noise pollution problems, TIAC drawn over NT $10 hundred million to replace 40 set air bridges, 40 set pre-conditioned air (PCA), and 26 set fixed electrical ground power (FEGP) in Terminal 1 &2 from 2012 to 2017.

The difficulty of the project was how to minimize the impact on airside operation, especially in the circumstance that TIAC has already met the problem that the number of passengers has exceeded the designed capacity of terminals. Therefore, the construction period was extended around 2 years because of halting construction in summer and Chinese New Year vacation each year. The project team devoted time to coordinate and negotiate the schedule of replacing and inaugurating each air bridge among airside management departments, airlines, ground companies, and airline operator's committee (AOC). The first new air bridge with PCA and FEGP was completed in May 2015 and the whole project was finally completed in July 2017.

For maximize the utilization rate of green airport infrastructure, TIAC made some amendments to the fare of using airport infrastructure in September 2017.The fact is it indeed increases the utilization of PCA and FEGP under the situation that airlines need to pay the same fare whether or not use these airport infrastructures. Compare to 2017, the monthly average utilization of PCA and FEGP grew by 75.8 percent sharply, the reduction in the fuel burn of aircrafts was 10.2 million kilograms, and CO2 emissions decreased by 32.2 thousand tonnes in 2018.

Project Graphics



The Utilization of PCA & FEGP in TIA Terminal 2 from 2012 to 2018

New PCA & FEGP in TIA are compatible to A380

New PCA & FEGP in TIA are compatible to B777-300ER

New PCA & FEGP in TIA are compatible to A321

Green Building Design

Tirupati Airport
Construction of New Integrated Terminal Building at Tirupati Airport

Tirupati Airport is famous for Tirumala Venkateswara temple located in the hill town of Tirumala, Chittoor district of Andhra Pradesh, India. The temple attracts Crores of pilgrims round the year both National and International and visited by about 1,00,000 pilgrims daily, while on special occasions and festivals like the Brahmotsavam, the number of pilgrims shoots up to 5,00,000. Andhra Pradesh State Reorganization act, 2014 mandated Government of India to develop Tirupati Airport as per the International standards. Accordingly, this project has been taken up. The capacity of Newly constructed Integrated Terminal Building (NITB) is 700Pax.

NITB is of 22500 Sq.m area. The modern see through concept building with maximum use of glass and steel structure facilitate natural lighting during day time, double height (Approx. 20mtr height) terminal building provides aesthetic local art. The building shape is designed in the form of “Garuda- carrier of Lord Vishnu”. City side of Terminal building provided with beautiful garden of 38 Acres from SriKalahasthi National Highway provided (with view cutter trees at both sides leading up to Car park of terminal building -Approx. 2.5 Km length of 4 lane road with median).

Latest modern terminal building with world class facilities like Passenger Boarding Bridge, Escalators, Elevators, Arrival claim carousels, Centralized air-condition, FIDS provided to passengers. Due to maximum use of glass and steel structure a see through for entire area was created, energy saving due to use of glass especially during day time, innovative latest profile roofing resulted in cost and time saving.

GRIHA (Four Star rating) award has been achieved for Green (Renewable Pollution Free) Airport.

All conventional lights in the NITB have been replaced with LED lights as a part of energy conservation measure, recently and the installation of 1 MWp solar plant is in progress.

Project Graphics

Design concept of Building with local heritage.

Front view of New Integrated Terminal Building with green garden.

Airside view of Terminal Building

Check-in area of Terminal Building

Section 2: Clean Energy Facility

Chubu Centrair International Airport
New Hydrogen Station for Fuel Cell Forklifts

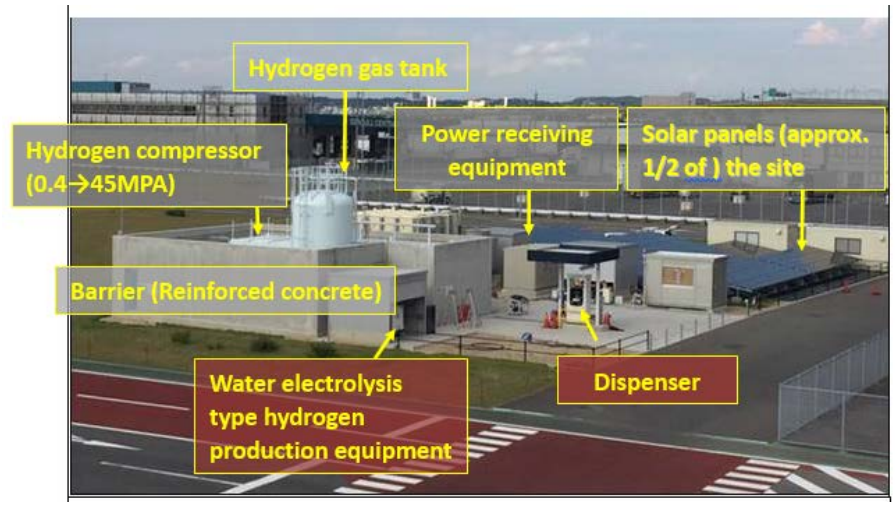
Chubu Centrair International Airport (“Centrair”) was engaging in practical research for introduction of fuel cell vehicles like forklifts to the airport site at the working group in collaboration with Aichi Prefectural Government, Toyota Motor Corporation, Toyota Industries Corporation and Suzuki Shokan Co.,Ltd. under initiative of Aichi Prefectural Government to develop hydrogen community in the region.

As one of achievements of the research, a new hydrogen station for fuel cell forklifts began its business in the cargo area of the airport on November 2, 2018.

This facility is the first ever one for commercial purpose in Japan that supplies hydrogen partly produced by homemade electric power generated from recyclable energy with solar panels in the airport site. In this regard, the facility is certified as “Low Carbon Hydrogen Generation Facility” by Aichi Prefectural Government that set up “Low Carbon Hydrogen Certification System”.

Project Graphics

Chubu Centrair International Airport Island Cargo Area in aerial view



New Hydrogen Station in panoramic view

Newly introduced 7 fuel cell forklifts at the opening ceremony

Clean Energy Facility

Kansai International Airport
KIX Hydrogen Grid Project

At Kansai International Airport (KIX), Kansai Airports Group is aiming to the "advanced environmental airport" that promotes the use of hydrogen as a new energy, with a view to the arrival of a hydrogen society. As a demonstration project of a hydrogen supply chain model in the airport community, we are engaged in attracting infrastructure facilities that can be used by fuel cell forklifts and Fuel Cell Vehicle (FCVs).

We established the "KIX Hydrogen Grid Committee" in cooperation with municipalities and enterprises in 2012. This committee started to consider about "Practical use of fuel cell forklift and construction of optimal hydrogen infrastructure facilities" and " Construction of hydrogen station for FCV".

In 2013, KIX was designated as "Kansai Innovation International Strategy Comprehensive Special Zone" by government, and It became an area where can be conducted about special regulations related to the development of hydrogen facilities and tax system support measures.

Iwatani Corporation, a member of the committee, developed provisional hydrogen filling facilities (462 ㎡) in 2015, hydrogen station for FCVs (2,479 ㎡) in 2016, and hydrogen filling facility for industrial vehicles (1,081 ㎡) in 2017 with utilizing national subsidies.

For practical application of fuel cell forklifts, we demonstrated operation with Toyota Industry, Iwatani Corporation and cargo operators from 2015 cooperated in technology development aiming for full-scale market launch. As a result, the first vehicle was delivered to KIX in Nov. 2016. In order to further expand the use, we have asked the government and Osaka pref. to set up subsidies, and 7 FCFLs have been operated in this year.

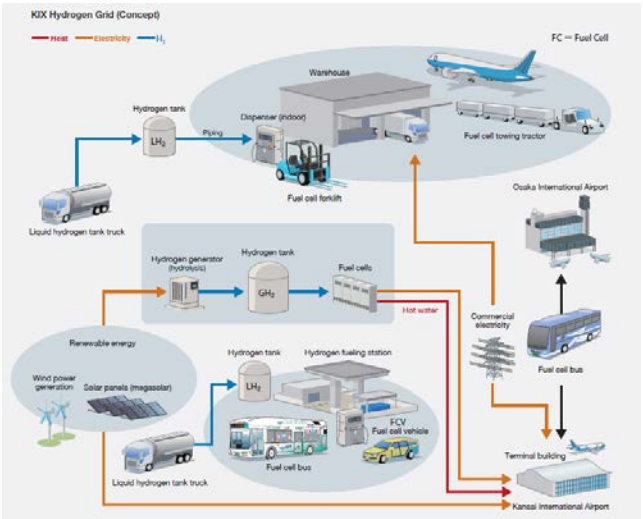
Kansai Airports Group also considers to introduce a fuel cell bus, and is working on the "KIX Hydrogen Grid Project" to realize the Smart Airport at Kansai International Airport.

Project Graphics

Hydrogen station for industrial vehicles

Fuel Cell Forklift

FCV and Hydrogen station



KIX Hydrogen Grid Image

Clean Energy Facility

Suvarnabhumi International Airport
Electric Vehicles

AOT has participated in ACI *Airport Carbon Accreditation* Programme since 2012 in order to progress towards international, national and company targets to reduce carbon emissions. Various measures have been implemented namely changing lighting system to LED, carpooling and changing executives' car to hybrid vehicles etc. AOT's executives realize that surface access plays a large part in carbon emissions for airport's operation, especially in Bangkok where there is high traffic congestion.

Therefore, the company management has agreed to cooperate with Electric Vehicle (EV) company in a form of co-branding to provide green transportation option for airport passengers. AOT provides counter, parking space and space for charging station. Meanwhile, EV company invests in vehicles and supporting equipment. EV taxi can travel up to 400 kilometers for each charging using Li-ion Fe 80 kWh battery. Traffic congestion does not affect electricity consumption as the vehicle will be switched into electricity saving mode.

In comparison, carbon emission from electricity consumption of EV taxi is about 16 times less than carbon emission from fuel consumption of conventional car. This is also cost effective as the cost of fuel consumption is eliminated while maintenance cost is lower. Moreover, it is now in the process of installing more charging stations at airport terminals, AOT headquarter and along tourist routes.

The charging station company also produces its own alternative energies including biodiesel, solar energy and wind energy. Therefore, once these stations are installed, it can be said that EV taxi releases zero emission. Many stakeholders are involved including AOT managers, EV company, charging station company, AOT staff and passengers. Later, the project will also be implemented at Don Mueang International Airport.

Project Graphics

Taxi stand for electric vehicles.

Charging station located at Suvarnabhumi Airport.

Signage on where and how to use EV taxi.

EV taxi is spacious that it can accommodate many suitcases.

Clean Energy Facility

Sydney Airport
SYD Renewable Power Purchase Agreement ("PPA")

Sydney Airport (SYD) has led a truly innovative Corporate Power Purchase Agreement ("PPA"), the first transaction structure like this executed in the Australian market. The long-term agreement sources energy from Crudine Ridge and Sapphire Wind Farms for ~75% of SYD's current electricity load. The bespoke agreement between SYD, Origin Energy and Grassroots Renewable Energy (a partnership of Partners Group and CWP Renewables) allows SYD to contract wind energy and bundle it with firming energy in one package. Through this SYD will meet its load and reliability requirements and support the business transition towards a low carbon future.

As part of SYD's business-wide energy strategy, many options for "greening" infrastructure were considered, including on-site generation (owned and offtake agreements), off-site generation (owned and offtake agreements). The PPA option was chosen as the optimal way to green SYD infrastructure as it is the most economically effective, simple to manage whilst still providing ongoing load management flexibility, took into consideration the significant physical and operational constraints of the airport and provided SYD a reliable & resilient energy supply via the firming component of the agreement.

This innovative arrangement enables SYD to de-risk energy costs under attractive terms, while supporting and fostering the growth of renewable energy in Australia.

The long-term agreement is linked to the Sapphire Wind Farm in northern NSW and the Crudine Ridge Wind Farm in Central West NSW. Crudine Ridge will have 37 wind turbines and 135 megawatts capacity, capable of generating 400,000 megawatt hours annually, reducing Australia's CO2 emissions by around 360,000 tonnes every year, the equivalent of almost 80,000 fewer cars on the road. Until Crudine Ridge is fully operational, the agreement is linked to Sapphire Wind Farm.

Project Graphics

The Sapphire Wind Farm is pioneering large scale community investment into the project (the first time this has been done in Australia)

A Sapphire wind turbine being erected

Three operational Sapphire turbines

Sapphire wind turbine standing proud

Section 3: Energy Efficiency Improvement

Adelaide Airport
SMART Building Analytics

Adelaide Airport is the fifth busiest Australian airport, with just over eight million passengers passing through last year. In 2017, Adelaide Airport was ranked 1st out of 13 participating airports worldwide in the Global Real Estate Sustainability Benchmark (GRESB). This significant achievement was preceded by being the first Australasian airport to be awarded certification to Level 3 of the Airports Council International *Airport Carbon Accreditation* programme.

Maintaining and extending this track record in sustainability is essential for airport management, especially in the face of a $165 million expansion that started in 2018 to cope with faster-than-expected passenger growth. Extending the airport's carbon footprint in the face of climate change requires both early intervention and finding new ways of operating building stock, the largest consumer of energy across most airports.

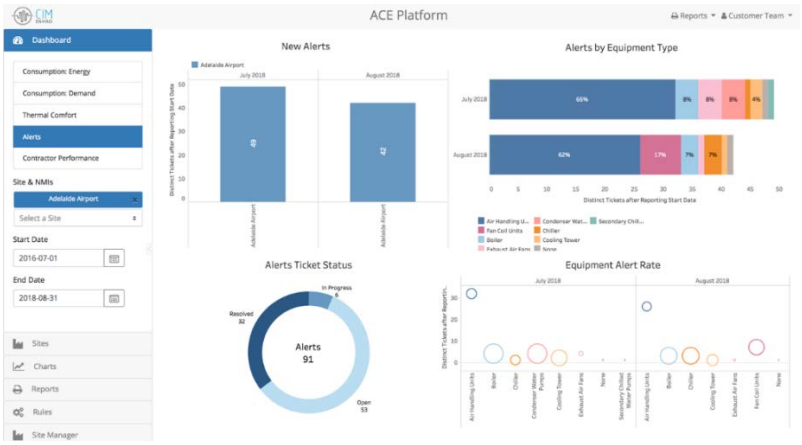
In 2018, the Australian government agency responsible for scientific research, CSIRO, identified a four-year-old building analytics industry coming out of Australia as 'emerging best practice' for reducing building carbon footprints, using Big Data.

With a commitment to both sustainability and fostering the next generation of Australian technologies, Adelaide Airport partnered with SMART building analytics startup, CIM Enviro, to deploy their ACE Platform building tuning software across Terminal 1. In so doing, Adelaide Airport became an early mover in the adoption of new innovation from this emerging Prop-Tech industry.

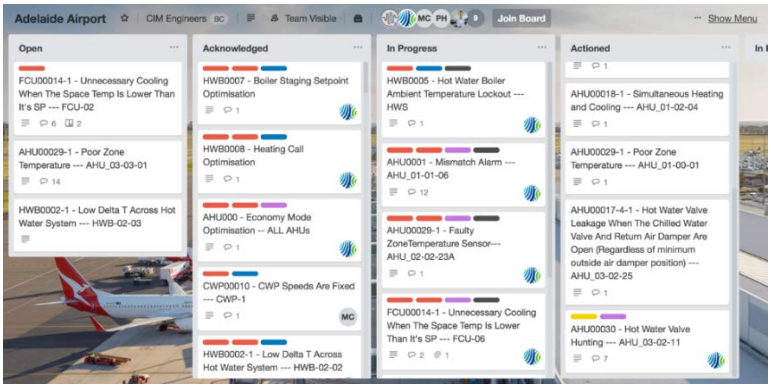
By installing a data acquisition device, the size of a mobile phone, the ACE Platform is able to provide on-site maintenance teams with real-time actionable insight on how to optimise energy across Terminal 1 and exceed design performance expectations.

Only six months into a three-year partnership and the analytics are already on track to deliver savings of 600tCO2e and 933MWh, for a 71% return-on-investment, demonstrating the benefits of big industry collaborating with emerging innovations that deliver more for less.

Project Graphics



ACE Platform | Maintenance Management Dashboard



ACE Platform | Maintenance Workflow Management Dashboard

Sarah Crowder (Adelaide Airport) accepting the SA Climate Leaders Finalist Award (2018)

Energy Efficiency Improvement

Hamad International Airport

LED for Apron Flood Lights at the Hamad International Airport

As one of the many continual improvement works at the Hamad International Airport (HIA), the State of Qatar, a project has been completed since November 2017 to improve Apron Flood lights performance by changing from High Intensity Discharge (HID) lights to Light Emitting Diode (LED).

The project was initiated in 2016 with mock-up and trails for two parking stands. After careful analysis on the stakeholders' feedback, operational impacts and business benefits, the actual works were approved and executed starting from Jun 2017.

Upon successful completion of the project for 150nos high mast lights with 1154nos luminaires, an annual electrical reduction of 2,336,668 KWH (50% comparing with period using HID lights) was recorded as of one of the major achievements, which allows HIA to save USD 204,858 on electrical bills.

With the advanced features of LED, HIA has achieved an annual saving of USD138,471 on maintenance activities of the apron flood lights by reducing the man-hours and spare parts. This has also improved the business efficiency through enhancing the availabilities of the lighting assets and parking stands.

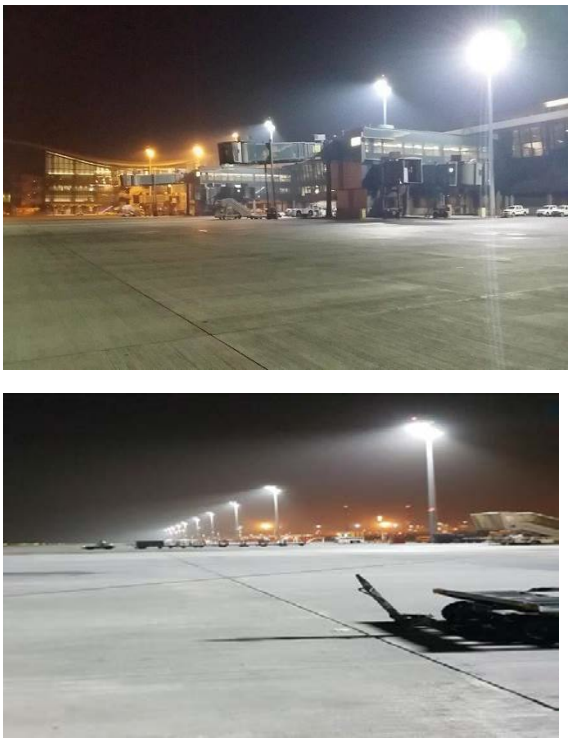
In addition, the project is beneficial to the safety and security functionalities through lowering the glare and improving the lighting intensity and colour rendering at the Apron and GSE roads of the airport. Positive feedbacks from concerned airport stakeholders were received through a formal survey.

A reduction of 1,137tons of carbon emission per annum has been achieved through the project, which has significant contributions to HIA's target to improve carbon efficiency per passenger by 30 percent by 2030 against a 2015 baseline.

In order to enhance the awareness of energy saving and carbon reduction and its impact on the environment, the project was also communicated internally and externally through various workshop, conference and media.

Project Graphics

New LED type R4 Vs HPS Light systems and New LED lights Type F32



Apron Stands Lighting LED Vs HPS Before and After new lighting system Replacement and Juliet Stands Apron Lighting After Replacement

Enegy consumption Measurement , CO2 Emission and Cost Saving Calculations for the Duration of Regular Annual				
Light ITEM	Energy Consumption (kWh)	CO2 Emission (Ton)	Energy Cost (QAR)	Harmonic Power (KVAR-H)
Lighting Type	kWh	Ton	QAR	
Old HID	4,660,884.5	2,268.7	1,491,483.0	2,600,083.6
New LED	2,324,216.2	1,131.3	743,749.2	9,970.4
Duration Annual	Energ Saving (kWh)	CO2 Reduction (Ton)	Cost Saving (QAR)	Hramonic Power Reduction (KVAR-H)
Saving and Reduction Amount	2,336,668.3	1,137.4	747,733.9	2,590,113.2
Saving and Reduction %	50.1%	50.1%	50.1%	99.6%

Energy Efficiency Improvement

Queen Alia International Airport
LED light installations on both Runways at QAIA

QAIA (Queen Alia International Airport) was inaugurated in 1983, the airport extends across 19 million SQMs and includes two parallel runways 3,660 meters in length, 61 meters in width and with a separation of 1,446 square meters.

In November 2007, through a 25-year concession agreement, Airport International Group (AIG) became the Jordanian company responsible for the operation of (QAIA), the rehabilitation of the airport's facilities, and the construction of the new passenger terminal.

Apart of the new terminal construction and the additional passenger capacity which reaches 12 Million passengers, AIG launched initiatives to enhance environmental management at the airport which eventually entitled QAIA to become the first airport in the Middle East to achieve ACI's *Airport Carbon Accreditation*-level 3 + (Neutrality) in April 2018.

In 2013, an internal assessment conducted on the operational and infrastructure status of the South and North runways, which included the existing equipment, frequency of corrective maintenance, runway pavement, power failures and energy consumption rates of the old halogen lights.

Based on the assessment was decided to change the lighting fixtures for both runways by end of 2017. The project implementation phases were:

- In Q3 2014 started at South runway and ended in December 31st 2016;
- In Q3 2015 started at North runway and ended in Q3 2017

The project works scope included but were not limited to changing the lighting fixtures of the Centerline, Touch Down Zone, Edge lights, Threshold and Approach lights of both runways

In QAIA, we are proud that all Airfield lighting units at the two runways are LEDs, where this feature helps reducing the energy consumption from both runways as below:

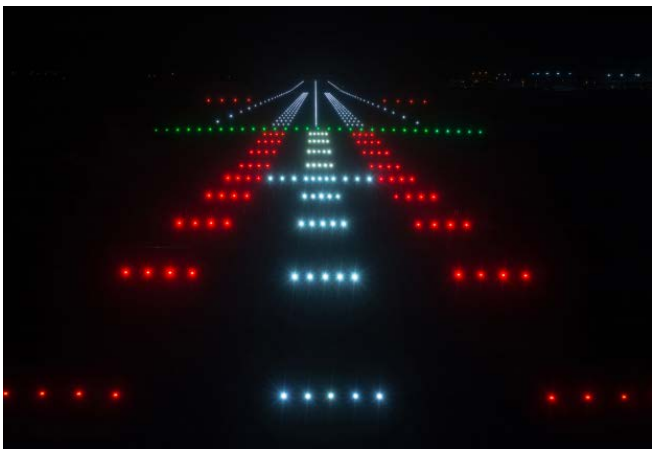
Total Saving-Annually	South RWY	North RWY
Power saving	779454KWh	596450.88KWh
Saving cost-power consumption	103667 JD	79240JD
CO2 emission reduction	495T annually CO2 per annum	216.5T CO2 per annum

Project Graphics

North runway –day light view

Approach light-26R-North runway

Approach light-08L-North runway



North runway-night view

Energy Efficiency Improvement

Sharjah Airport
New taxiway lighting project

As a part of continuous effort to ensure a reduced energy consumption and minimum carbon footprint Sharjah Airport always try to impart a green approach to any new or retrofit project it undertakes.

A new runway was built in line with its expansion plans to meet the increasing market demand and the old run way was planned to upgrade to taxiway bravo which required to install with the new taxiway lighting system. In line with its focus on continuous efforts to reduce energy consumption and reduced carbon footprint Sharjah Airport decided to go for latest energy efficient LED lighting system with minimum environmental impact. The area's where covered under the new taxiway lighting system were, taxiway centerline lights, stop bar lights taxiway edge lights, runway guard lights and stop bar elevated lights.

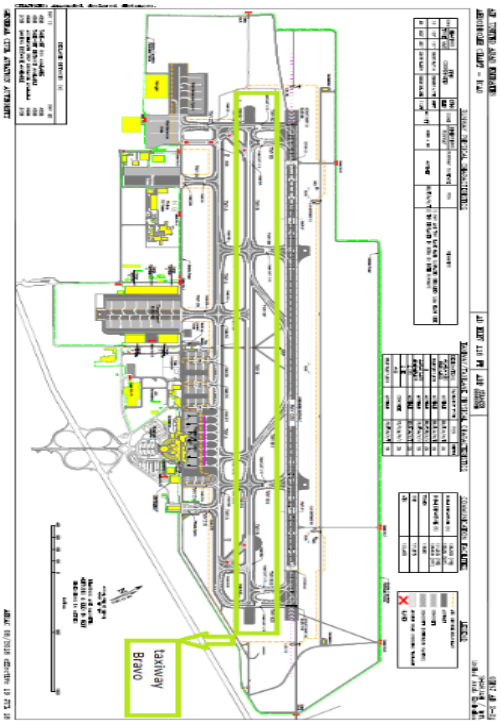
The project includes the installation of LED lighting system at the newly upgraded taxiway bravo which was the old runway. By choosing LED lighting system for the new taxiway Sharjah Airport manage to avoid a marginal amount of energy consumption and carbon footprint by not using conventional halogen lighting system which is used in the old taxiway.

A total number of 1351 LED lights were installed out of which 20 numbers are 62watts and the rests are 10 watts. The new generation LED lighting system installed at the taxiway bravo also have advanced features such as individual lamp control and monitoring facility which is a part of ASMGCS and initial step for future upgrade from CAT1 to CAT111B. The new LED lighting system will reduce the taxiway lighting power consumption and proportionate carbon footprint to almost 80% compared to the halogen lighting system used in the taxiway alpha.

Project Graphics

Elevated LED Stop Bar lights X 4

Inset LED Stop Bar lights X 1



SIA Aerodrome Map. Highlighted is Taxiway Bravo

Taxiway Bravo LED Center line lights

Section 4: Water Efficiency Improvement

Kuala Lumpur International Airport 2

Innovative Water Recycling from Rain Water Harvesting (RWH) & Air Handling Unit (AHU) Condensation Foresight to Supply Non-Potable Water System

Kuala Lumpur International Airport 2 (klia2) is the largest terminal to cater for the explosive growth in low-cost travel industry and servicing 45 million passengers a year.

On top of that, Engineering Division Malaysia Airports Holdings Berhad (MAHB) has continuously strive on improving the business and services by leveraging on Innovative Water Recycling from Rain Water Harvesting (RWH) & Air Handling Unit (AHU) Condensation Foresight to Supply Non-Potable Water System facilities at klia2 airport towards a long term local and global environment sustainability. It is in tandem with global trends developments in the new generation 'green airport' in aviation industry.

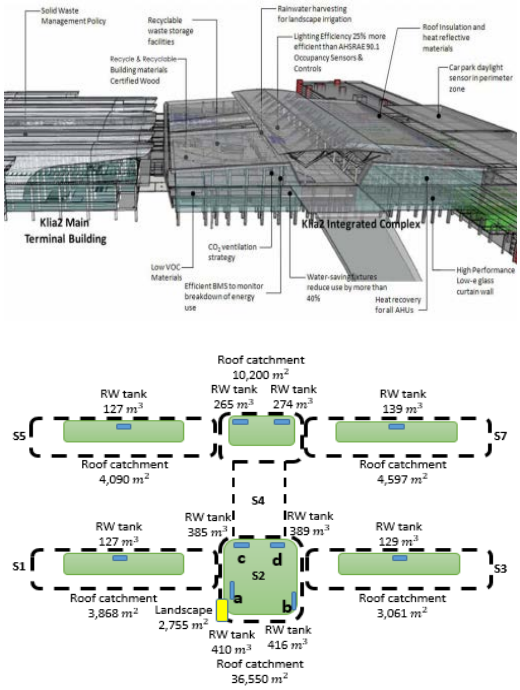
The balance increasing water demand and available fresh water sources is the most concern at klia2. Sourcing from the sky - Rain water harvesting is a technique of collection and storage of rainwater into natural reservoirs or the infiltration of surface water into subsurface aquifers (before it is lost as surface runoff). Rain water is captured from rooftop areas and condensate water is collected from 288 AHU units before being filtered. Collected water is retained within the storage tank located underground, away from heat and sunlight which ready to be used for toilets flushing and plants irrigation.

Consultant reported that RWH & AHU Condensation was able to provide 24,892 kGal of non-potable water yearly which contributed to 107% of the total 21,422 kGal of non-potable water consumed at klia2 yearly.

This report provides an overview, analysis of performance and its impacts in terms of financial, water sustainability, airports image and passenger awareness. Method of analysis inclusive reduction of water consumption from water service provider and total operational expenditures which lead to contribution of klia2's water generation.

As overall, this project exemplifies good significant impacts in water sustainability, saving in financial, increase reputation and achieved the target for green airports infrastructure.

Project Graphics



Airport Layout with catchment area & tank

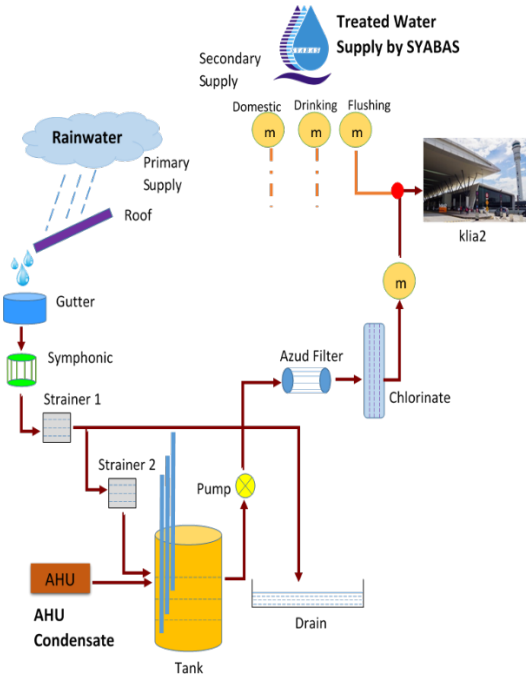
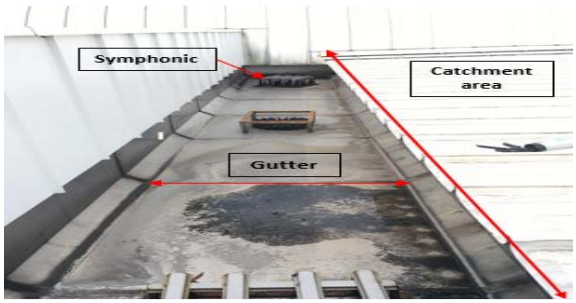


Diagram of RWH & AHU Recyling Water



AHU Collection Vessel

Fundamental of installation at site

Water Efficiency Improvement

Rajiv Gandhi International Airport

Rainwater Harvesting at RGIA: An efficient Ground Water Recharge and Surface Water Usage Practice

Since inception, sustainable development has been the core theme of GMR Hyderabad International Airport Limited (GHIAL). GHIAL is operating Rajiv Gandhi International Airport (RGIA) with a focus on conserving natural resources by practicing 4Rs concept- Reduce, Reuse, Recycle and Replenishment towards environmental protection. GHIAL has implemented water conservation projects including rainwater harvesting at large scale and set an industrial benchmark in the efficient water management

When the Pollution Control Board mandated RGIA not to discharge storm water from its premises, GHIAL saw this as an opportunity rather than a challenge and worked to develop a rainwater harvesting project within the airport. Because of the natural sloping topography, the Airport has high potential for harvesting rainwater run-off from its paved areas like apron, taxiways, runways and rooftops. During monsoon (June to September), this extensive run-off is collected in the water holding tanks through an integrated network of drain structures within the Airport boundary.

The harvested rain water is effectively recharged into the ground by using artificial recharge wells, which augment ground water table in and around the airport. Apart from this, the precious resource is also utilized for flushing and irrigation to reduce the intake of the municipal water supply, which is used by the municipality to serve the needy local communities.

Other Tangible benefits:

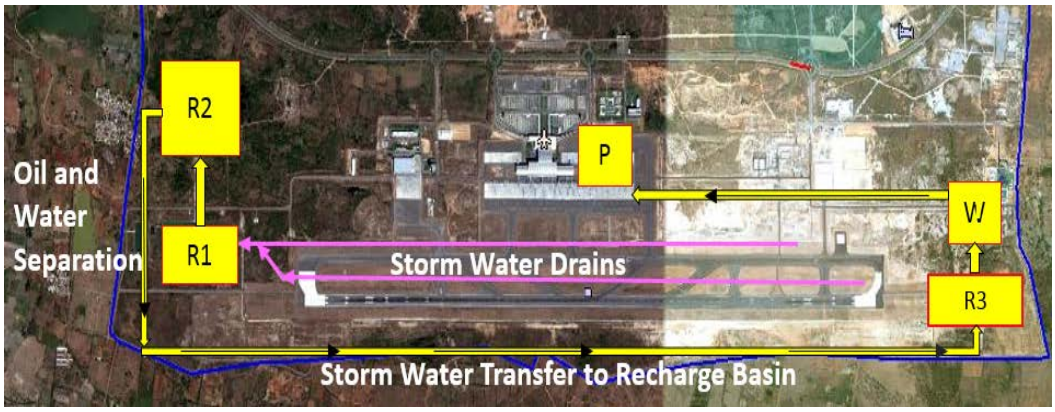
- The project helps the airport to meet nearly 25% of its water requirement from the surface water for nearly 6 months (June - November) every year with a cost saving of ~ INR 1.05 million/ annum

- By harvesting storm water, augmenting ground water table in and around the Airport.

- Contributing to the U.N. Sustainable Development Goal 6: Ensure Availability & Sustainable Management of Water and Sanitation for All.

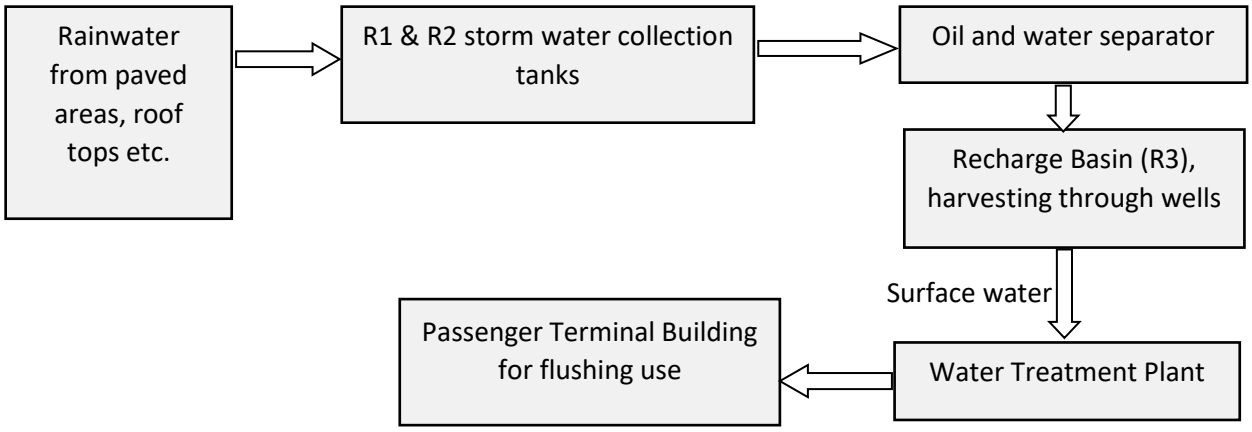
RGIA is aiming towards becoming water neutral airport by replenishing to the nature.

Project Graphics



R1: Storm water collection tank; R2: Additional water storage reservoir
R3: Storm water recharge station; W: Water treatment plant; P: Passenger Terminal Building

Rain Water Harvesting Flowchart:



Rainwater harvesting structure (R2) at the Airport

Ground water recharge wells at the recharge basin (R3)

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