المنظمة العربية للطيران المدني
Arab Civil Aviation Organization

تحفيز المطارات
وفق أفضل الممارسات في مجال حماية البيئة
- المراجع -
يوليو - 2021

Source references:

A) ICAO

1) AIRPORTS AND OPERATIONS WORKING GROUP (WG2) /CAEP
2) Airport Planning Manual
3) Airport Air Quality Manual (Doc 9889)
4) Operational Opportunities to Reduce Fuel Burn and Emissions (Doc 10013)

B) Other

1) Research Gate provided by Dr. Ali Shaar "Solid Waste Management in Lebanon: Challenges and Recommendations " https://www.researchgate.net/publication/331378505;

Airport Planning Manual Eco-Airport Toolkit

SUMMARY

The Eco-Airport Toolkit e-collection, assigned to WG2 for the CAEP/12 cycle. To provide an update of progress made since the last meeting, including the draft **e-publication Air Quality Management at Airports**.

1. INTRODUCTION

1.1 At CAEP/11, agreement was given to WG2 to continue Task O.08, entitled "Eco-Airport Toolkit E-Collection." The task has the following description:

"A set of practical and ready-to-use information documents, to support the planning and implementation of airport infrastructure projects that envisage significant environmental benefits. Each publication will focus on a specific example of environmental planning at airports. The deliverables will be a series of short publications accessible from ICAO Environment website and will form an e-collection. "

1.2 The objective of the task is to extend the scope of selected topics included in the updated ICAO Doc 9184 Airport Planning Manual, Part 2, Land Use and Environmental Management, by providing more detailed information and useful guidance. The deliverables of this task, the "e-publications", are intended for use by States, airport operators, and regional and local authorities that are planning airport infrastructure projects, particularly in regions in which the aviation sector is growing. The e-publication themes were chosen on the basis of emerging challenges related to environmentally sustainable infrastructure and operations in aviation.

**** Below is the list of e-publication topics initially proposed by the CAEP/11 meeting:-**

1) Renewable energy at airports (completed)

2) Airport Environmental Management Systems (completed)

3) Waste management at airports (completed)

4) Eco-design of airport buildings (completed)

5) Climate resilient airports (completed)

6) Water management at airports (approved at SG2020)

7) Air Quality Management (drafted)

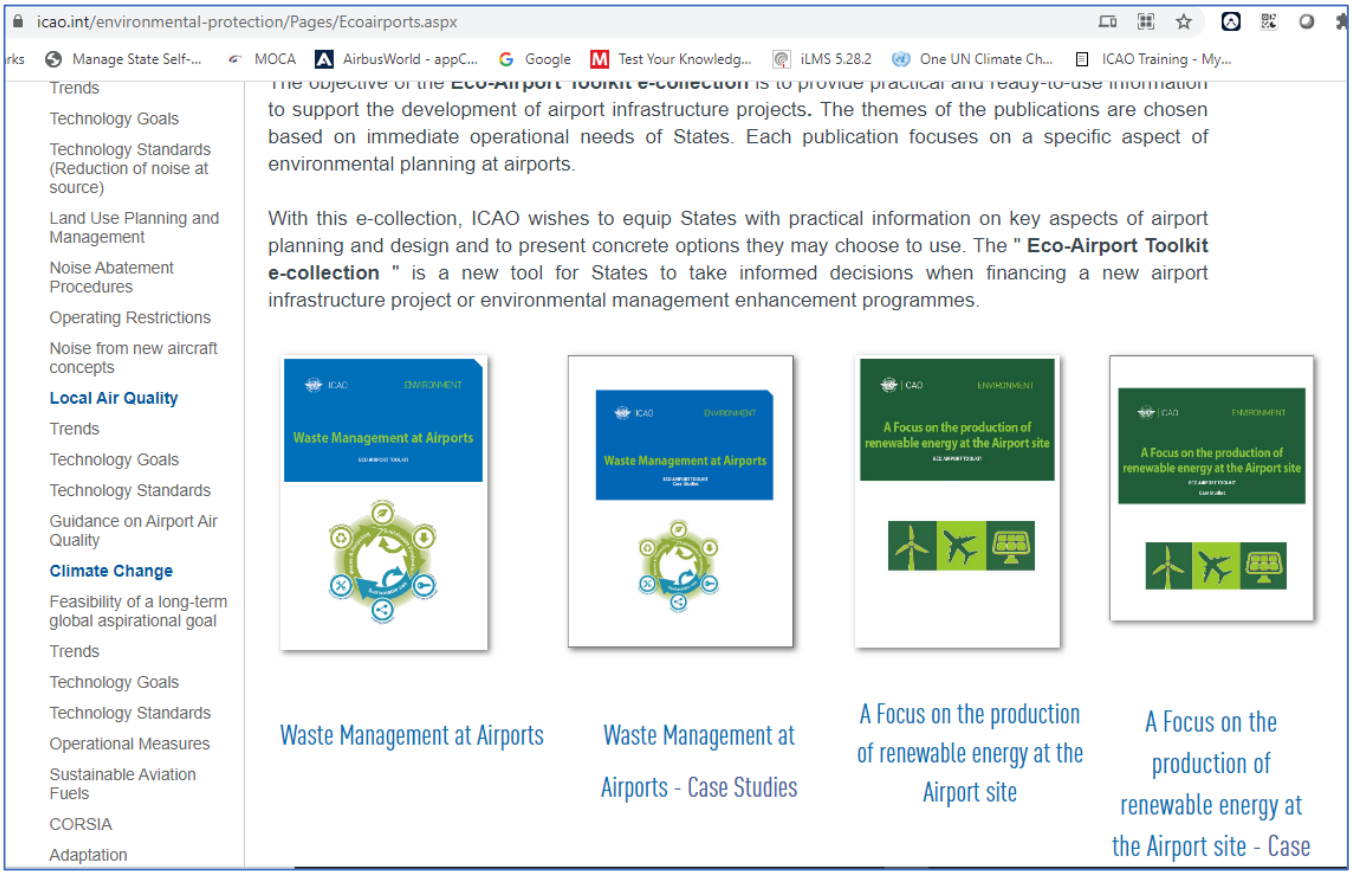
8) Green airport surface access

9) Airport and noise abatement (based on ICAO Document 9829 – Guidance on the balanced approach to aircraft noise management, on ICAO Document 9184 – Airport Planning Manual, Part 2, and on ICAO Document 9888 – Review of noise abatement research and development and implementation projects)

1.3 The **first four e-publications are available at this site**,

https://www.icao.int/environmental-protection/Pages/Ecoairports.aspx

along with **case studies for Renewable Energy at Airports, Waste Management at Airports, and Eco-design of Airport Buildings.** No case studies were prepared for Airport Environmental Management Systems (EMS), given its maturity and the wide range of material already available to support those organisations implementing an EMS.



1.4 The following topics were approved at the CAEP/11 meeting to be completed in CAEP/12:

— Climate resilient airports;

— Water management at airports (including glycol management);

— Air quality management; and

— Green airport surface access.

From The ICAO website abovementioned; attached are the all available files together in one file as follows.

ICAO

ENVIRONMENT

An Environmental Management System for Airports

ECO AIRPORT TOOLKIT

OUTLINE

ICAO ENVIRONMENT

An Environmental Management System for Airports

ECO AIRPORT TOOLKIT

International Civil Aviation Organization (ICAO)
999 Robert-Bourassa Boulevard, Montréal, Québec H3C 5H7, Canada

1. INTRODUCTION

"An Environmental Management System (EMS) provides a methodology and framework to systemically identify and cost-effectively manage significant environmental aspects of aviation organizations' operations and have proven effective across a wide range of organizations, including airports, air carriers, manufacturers and government agencies."[1] EMS is one of the tools available for managing environmental matters at an airport, along with sustainability plans, certifications such as Envision[2], and other processes.

This fact sheet is intended to help airport operators understand what an EMS is about, and decide if they would like to develop one for their facility[3]. It also provides guidance on implementing an airport EMS.

2. WHAT IS AN EMS?

An Environmental Management System (EMS) is a set of management principles intended to identify, evaluate, monitor, and reduce the negative environmental impacts of an organization's activities. It benefits an organization by offering a systematic approach for assessing and controlling ongoing activities, increasing environmental awareness, and complying with relevant regulations. An EMS provides many different and useful tools for detecting, understanding and managing those elements involved in its activities, products and services which have the potential to impact the environment.

The International Organization for Standardization (ISO) defines EMS as the part of the management system that is used to manage environmental aspects, fulfil compliance obligations, and address both risks and opportunities[4].

According to the US Environment Protection Agency (EPA), "an Environmental Management System (EMS) is a set of processes and practices that enables an organization to reduce its environmental impacts and increase its operating efficiency[5]."

The Standards Council of Canada (SCC) explains that an EMS should be able to verify the impacts of an organization on the environment and help it to establish environmental goals and targets, and to evaluate how well they are being achieved[6].

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1 *ICAO Doc. 9968: "Report on Environmental Management System (EMS) Practices in the Aviation Sector" page 1-2.*

2 *See https://sustainableinfrastructure.org/envision/*

3 *The ICAO Committee on Aviation Environmental Protection (CAEP) asked one of its Task Groups "Land Use Planning and Noise Management" at the CAEP/7 cycle (February 2007), to deliver a report at CAEP/8 cycle (February 2010), on the feasibility of using Environmental Management Systems (EMSs) in the aviation industry. In addition, and as appropriate, the TG was also asked to make recommendations on how CAEP could promote the use of EMS within the aviation system. Therefore, the TG developed an industry questionnaire to better understand the application and potential value of EMSs to aviation organizations. The questionnaire, in accordance with the request from an ICAO State Letter, was distributed worldwide in May 2008 by Member States and international representative organizations, categorized into five different types of respondents, covering Air Navigation Services Providers (ANSPs), airlines, airports, manufacturers and other aviation organizations. Information from 233 organizations, out of 326 that responded to the questionnaire, formed the basis of the Report to CAEP/8 after validation of the data. The responses also served as the basis for two recommendations, which referred to the dissemination of the information from the report, and the consequent development of a guidance document on EMS - ICAO Doc. 9968: "Report on Environmental Management System (EMS) Practices in the Aviation Sector". The following are the Recommendations:* ***Disseminate report information.*** *Within the first year of the CAEP/9 cycle, ICAO should make the information contained in this report publicly available. A report should be distributed specifically to CAEP States and observers and to all survey respondents.* ***Develop EMS guidance.*** *Stand-alone EMS guidance should be developed for the end of the CAEP/9 cycle to assist organizations to determine how EMS elements and principles can be used to enhance the way they manage environmental issues, and provide practical guidance on how these EMS elements and principles can be implemented/integrated into existing management systems and business processes.*

4 ***ISO 14001:2015*** *page 2.*

5 ***U.S. Environmental Protection Agency (EPA) website:*** *https://www.epa.gov/ems*

6 ***The Standards Council of Canada (SCC) website:*** *https://www.scc.ca/en/accreditation/management-systems/environmental*

An effective EMS should be able to set a comprehensive framework to assist an organization in planning, implementing, mitigating and managing its environmental impacts, through a systematic, sustainable, transparent and accountable manner that is coherent with its environmental policy. The overall success of an EMS implementation relies on the engagement of all levels and functions of the organization[7].

2.1 Objectives

The main objective of an EMS is to effectively reduce the impacts of an organization's activities on the environment through a systematic management practice. For instance, in order to mitigate its environmental impacts, an organization has to plan in advance, create a corporate environmental policy and implement different sets of actions. The EMS aims to assist with this entire process.

2.2 International EMS Standards

Below are some often used EMS international standards:

ISO 14001: 2015 Standard

This international standard establishes best practices for an EMS implementation. Such an EMS can be implemented in different organizational models. ISO 14001:2015 is part of the ISO 14000 "family of standards" that focuses on management of an organization's environmental responsibilities, regardless of its type of activity. Specifically, ISO 14001:2015 is based on implementing environmental systems to achieve its objectives while other standards in the family focus on specific solutions such as audits, communications, labelling and life cycle analysis, as well as environmental challenges such as climate change[8].

ISO 14001:2015 summarizes how an EMS can provide added valued for top management to efficiently achieve long term success and at the same time contribute to sustainable development:

- protecting the environment by preventing or mitigating adverse environmental impacts;
- mitigating the potential adverse effects of environmental conditions on the organization;
- assisting the organization in the fulfilment of compliance obligations;
- enhancing environmental performance;
- controlling or influencing the organization's product life cycle;
- achieving financial and operational benefits; and
- communicating environmental information.

EMAS European Standard

The European Union Eco-Management and Audit Scheme (EMAS) is the EMS standard developed by the European Commission to evaluate, report, and improve an organization's environmental performance[9]. Like other international standards, EMAS is appropriate for many different kinds of organizational models – private or public, large or small. EMAS includes additional requirements beyond ISO 14001:2004 such as performance measurements, employee engagement and stakeholder involvement[10]. In addition, EMAS is also considered stricter than ISO 14001 and also provides legal security through compliance with environmental legislation ensured by government supervision. Table I below provides a comparison between EMAS version III and ISO 14001 version 2015[11].

Topic	Topic ISO 14001: 2015	EMAS: III
Basis	No legal basis, only based on ISO	EU Regulation EN/1221/2009
Goals	System oriented: Improvement of the environmental management system	Performance oriented: improvement of environmental performance
Requirements	ISO 14001: 2015	ISO 14001, plus: - Proof of compliance - Improvements of performance - Staff engagement - External communication - Providing environmental information
Internal Audits	Yes	Yes
External Audits	Re-certification audit every 3 years Surveillance audit annually	Re-certification audit every 3 years Validation of environmental report annually
External Organizations	No involvement	Involvement of environmental authorities
External Communication	Only providing accessibility	Required through environmental report
Legal compliance	Only process required	Proof required

Table I *- Comparison between EMAS III and ISO 14001: 2015*

3. BASIC EMS PRINCIPLES

EMS policy statement: top management commitment

The top management of an organization shall commit and express its leadership regarding an EMS through (at a minimum) establishing, implementing and maintaining an environmental policy that, provides a framework for defining environmental goals, and offers a commitment to protect the environment, in coherence with the organization's activities.

Additional leadership commitments are expected by the ISO 14001:2015, such as[12]:

- Providing conditions for the environmental policy to be implemented, to include ensuring necessary resources, support and internal coordination;
- Being accountable for the effectiveness of the EMS.

Planning

An organization using an EMS should identify the required processes and practices to address environmental aspects and compliance obligations, while also dealing with identified risks and oppor-

7 ***ISO 14001:2015*** *page vi.*
8 ***ISO 14001:2015 website:*** *https://www.iso.org/iso-14001-environmental-management.html*
9 *It was first developed in 1993 and revised in 2001 (EMASII) and 2009 (EMASIII)*
10 ***3x3 Good Reasons for EMAS:*** *http://ec.europa.eu/environment/emas/pdf/other/Brochure_3x3_Good_reasons_for_EMAS.pdf*
11 *See the* ***Fact Sheet*** *comparing ISO 14001 with EMAS available online: http://ec.europa.eu/environment/emas/pdf/factsheets/EMASiso14001_high.pdf*
12 ***ISO 14001:2015*** *pages 7-8.*

tunities. In order to address risks and opportunities, it is essential to understand the organization and its context, the needs and expectations of interested parties, and also to determine the scope of the EMS, through a comprehensive planning process[13].

Implementation and Operation

The criteria for required operational processes should be established, and required controls should be planned. The organization can also control the implementation of planned changes or improvements into the operational processes and make sure that outsourced processes are also controlled and influenced. Considerations of emergency preparedness and response, and consistency with life cycle perspectives, can also be part of this process[14].

Checking

The organization must continuously evaluate its environmental performance through monitoring and analysis. In this regard, it requires the use of specific methodology, appropriate criteria and suitable indicators that shall be defined in advance. Internal auditing and management reviews can also be part of the defined checking processes[15].

Management Review

The top management of the organization is in charge of reviewing the EMS at defined intervals, in order to guarantee its continued suitability, adequacy and effectiveness. These reviews should include the status of the actions from the previous reviews, including the changes that should be considered, determining which environmental objectives have been achieved, analyzing the overall environmental performance, the adequacy of resources and the opportunity for continuous improvement[16].

Continual Improvement

Through monitoring and evaluation, the organization is able to identify the opportunities for improvement and achievement of the defined environmental goals. This prospect should include the identification of errors and the decision to take corrective actions, in order to guarantee a continuous improvement[17].

Plan, Do, Check, Act (PDCA)

The PDCA principle is a continuous approach applied to both an EMS as a whole and each of its elements. In this regard, it is sort of a combination of the individual principles mentioned above.

- Plan: The advanced establishment of environmental objectives, along with the set of processes and practices necessary to achieve the defined objectives, and in accordance with the organization's environmental policy.
- Do: the implementation of the set of processes and practices according to the defined Plan.
- Check: Constant monitoring and assessing processes and practices compared to the defined environmental policy. Results of this evaluation must be reported.
- Act: take actions to continually improve[18].

13 ***ISO 14001:2015*** *pages 6-9.*
14 ***ISO 14001:2015*** *pages 13-14.*
15 ***ISO 14001:2015*** *pages 14-15.*
16 ***ISO 14001:2015*** *pages 15-16.*
17 ***ISO 14001:2015*** *pages 16-17.*
18 ***ISO 14001:2015*** *page vii.*

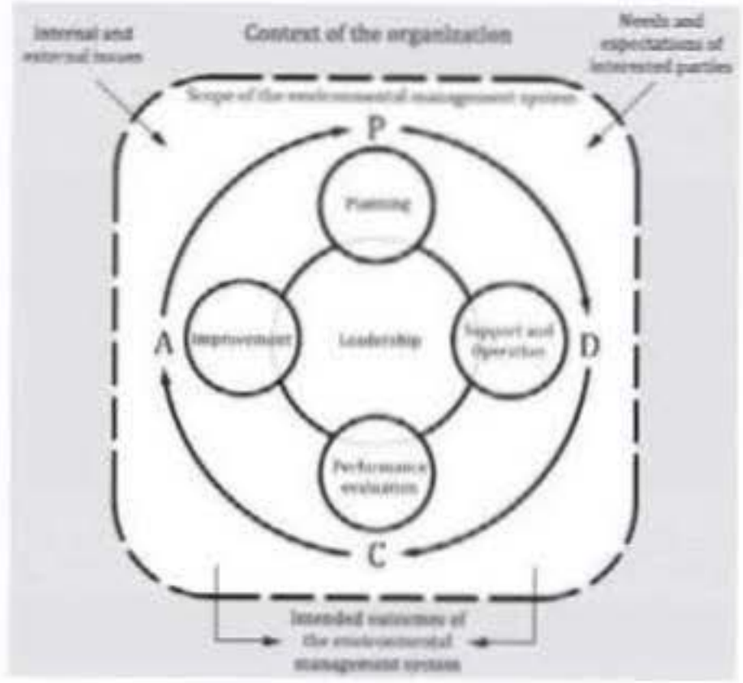

Image I – *PDCA cycle approach from ISO 14001:2015*[19]

4. BENEFITS OF AN EMS FOR AN AIRPORT

An EMS provides an organized and systematic means of managing environmental processes at an airport, which can result in multiple co-benefits. A well-designed EMS allows the airport to improve management of operations that have the potential for environmental impact, and to better track and report on regulatory requirements. The EMS process can simplify complex environmental issues by providing a structured framework that makes environmental management more efficient, reduces costs, and allows for continuous improvements in environmental performance.

An EMS improves internal airport management processes, and increases employee understanding of environmental issues and responsibilities. Airports with an EMS have reduced frequency and severity of environmental incidents, and improved compliance with regulatory requirements[20]. In addition, the EMS process facilitates reporting and compliance, and helps demonstrate the airport's due diligence in managing environmental issues. A major benefit of an EMS is to help an airport to identify if there are any gaps in its environment management program and assessment practices. By providing a comprehensive systematic approach to manage an environmental portfolio, the EMS is able to assess the overall completeness of the airport's environment program. This could also improve the health and safety of employees and the public. Together, these benefits amount to reduction in environmental risk, which is the primary benefit of an EMS.

A good EMS process will find synergies with other management systems, such as Airport sustainability planning, Airport Carbon Accreditation, Energy Management Systems (ISO 50001), or spe-

19 ***ISO 14001:2015*** *page vii.*
20 *Delaney, Elizabeth and Barbara Thomson, 2013, E****nvironmental Management System Development Process: A Synthesis of Airport Practice.*** *ACRP Synthesis 44, Transportation Research Board. U.S. National Academy of Sciences, Washington DC. (ACRP 2013, p. 24)*

cific programs for storm-water or air emissions. When the goals and activities of these various processes are integrated in an EMS, they can be implemented more efficiently and cost effectively.

Overall, a properly developed and executed EMS will lead to internal consistency by the airport in carrying out activities with environmental implications. An EMS does not relieve the airport of its environmental responsibilities, but it can reduce the costs and time associated with environmental analyses. This improved environmental performance, and the reduction of costs through enhanced efficiency, can help improve public relations. A certified EMS is a strong marketing tool for the airport, especially if it is planning to grow[21]. Table II below summarizes EMS benefits[22].

• Improved environmental performance.
• Reduced frequency and severity of environmental incidents as well as reduced non-compliance with regulatory requirements.
• Improved response to incidents, which may prevent or mitigate their impacts.
• Assistance in demonstrating due diligence.
• Assistance in meeting stakeholder requirements and/or expectations.
• Reduced environmental costs.
• Improved relationships with government agencies and NGO's.
• Reduced environmental risk.
• Synergies when implementing Airport Carbon Accreditation or the Energy Management System set forth in ISO 50001.
• Improved public relations.
• Improved internal consistency in undertaking activities with environmental implications.

Table II - *EMS Benefits*

5. BEFORE YOU START

Whichever the tool chosen to plan and implement an EMS process, it is necessary to consider some essential steps before starting. First and foremost, you need to define the scope of your organization's involvement. For instance, airports can be managed by more than one entity (e.g. one managing airside and another landside). It is also common to have one single entity managing several airports. Therefore, it is necessary to define the boundary of the EMS's implementation. This boundary could be defined by legal responsibility of the entity (e.g. the scope of a concession) or by location, (e.g. just that one particular airport in question).

In addition, the airport organization and its context should be understood in order to "determine external and internal issues that are relevant to its purpose and that affect its ability to achieve the intended EMS outcome(s). Those issues include environmental conditions capable of affecting or being affected by the organization." [23]

When engaging in an EMS process at an airport, it should be discussed with all the organizational parts that can contribute and participate in its development. The most difficult step is to define who is going to lead the entire process: it could be the airport administrator or the aeronautical authority. This should be defined at the beginning. It is important to convene a group of people that represents all the parts of the organization, in order to identify all the internal and external issues that can contribute to developing the airport's context. The team should be capable of describing and considering the organizational goals, policies and the human, technical and financial

21 Raftopoulou, C., C. N. Kavouras, and P. Karamanos, 2005, The Environmental Management System of the Environmental Services Department of Athens International Airport, Eleftherios Venizelos. Greenleaf Publishing
22 CSA Group, formerly the Canadian Standards Association (CSA)
23 Bidwell, Marek, 2015. Making the Transition to ISO 14001:2015. BMS Services. Web: www.bms-services.com [30-05-2017]

resources. Also, it should work on any other external variables that can affect the normal airport operations.

As described in section II, it is also necessary that the EMS is integrated with the goals and activities of the different processes that already exist at the airport. Incorporating the "context analysis" into the management review meetings will not only improve the understanding of the organization but also facilitate the understanding of the macro-environmental issues. [24] For a more structured description of how an airport EMS project can be prepared, please consult Table III below.

Element	**Content**
Situation	Context Analysis.
Goals	Describes the initiative and the anticipated goals. Environmental policy.
Responsibilities	Identifies who is responsible for the implementation (regulator, airport operator).
Interfaces/partners	Assembles teams of expertise.
Legal compliance	Describes the legal basis on which the EMS is based.
Environmental benefits	Qualifies and quantifies the environmental aspects associated with the different airport procedures. This includes an Initial Environment Review (IER).
Economic costs	Quantifies the costs associated with the implementation of an EMS and the relative cost-effectiveness of environmental management options, noting that there could also be cost savings associated with the measures (for example, social/government penalties).
Interdependencies	Describes potential trade-offs or interdependencies at the management of the environmental effects identified, and provides options to mitigate them.
Implementation	Gives some guidelines on how to implement and operate the EMS.
Time frame	Sets time frames or deadlines for implementation.
Evaluation	Gives an evaluation of the measure and a recommendation for implementation. Internal Environmental Audit.

Table III - *Airport EMS Project*

6. GETTING STARTED

24 Bidwell, Marek, 2015. Making the Transition to ISO 14001:2015. BMS Services. Web: www.bms-services.com [30-05-2017]

Airports can develop their management process in different ways. An effective example of an EMS cycle is described in the ISO 14001 standard: the 'plan, do, check, act' cycle. The general process of an EMS is described below, along with the major components found in most EMSs.

Some airports may prefer to hire a consultant to assist in developing an EMS, while others may want to develop it themselves. Either way the same information is needed. Getting started on the process begins with the following steps:

1. A clear environmental policy statement
2. An initial environmental review of the airport
3. An assessment of potential impacts
4. Development of targets to minimize impacts and address policy objectives

A clear environmental policy statement

The initial review can identify the extent to which the airport already has systems in place to manage environmental matters and where gaps exist that should be fixed. The policy statement should include the high-level commitments to prevention of environmental impacts, pollution, and waste, the satisfaction of legal and regulatory compliance obligations, and a commitment to continuous environmental improvements. The policy statement will often outline the airport's mission and vision, and should be tailored to the specific environment and operational needs of the airport. The policy statement must have support from senior airport officials, and should be signed by either the head of the airport's governing board, the senior executive, or a senior airport manager. In addition, the airport must ensure that all employees are aware of the policy and have an understanding of its contents.

An initial environmental review of the airport

The initial environmental review will require gathering information. Following the steps described in ISO 14001: 2015, the basic process is to identify environmental aspects at the airport and determine which of them can have a significant impact on the environment.

- An **environmental aspect** is an element of the airport's activities, products, and services that can interact with the environment in either a beneficial or negative way (e.g. consumption of materials, discharges, spills, etc.).
- An **environmental impact** is a change to the environment, beneficial or negative, resulting from the activities, products, or services.

An example of this environmental review is demonstrated by the Athens International Airport EMS, which covered the activity areas in the box below:

- Managing the environment (EMS)
- Air quality management
- Noise abatement
- Waste management
- Energy monitoring
- Water management
- Environmental auditing
- Bio-monitoring
- Bird control
- Public awareness and environmental education
- Preservation of cultural heritage

An assessment of potential impacts

To get started, identify the airport's environmental aspects, identify the potential impacts of those aspects, assess the significance of the aspects, and assess the level of control or influence the airport has over such aspects and impacts. This information gathering can be done through review of past environmental performance, review of documents and records, interviews with staff and stakeholders, and through direct observation/examination of the airport operations. Determining the significance of the potential impacts may require a ranking system or comparison with certain criteria such as cost, scale of risk, frequency of occurrence, or level of stakeholder concerns. A Leopold Matrix could be a useful tool in order to tackle this task[25].

It is essential to review the legal framework that applies to airport actions for the state in which the airport is located. Legal requirements applicable to airport environmental aspects can include such things as air and water quality regulations, energy use, noise restrictions, or handling of hazardous waste, for example. The EMS process must, at a minimum, satisfy any enforceable legal requirements. It can also simplify the process of documenting and reporting to state agencies and regulators.

Development of targets to minimize impacts and address policy objectives

When significant environmental aspects have been identified, the airport must develop objectives and targets for addressing them. These targets are specific performance requirements set by the airport, and will relate to specific airport operations and environmental aspects. Targets should be measurable, and might include things such as achieving a recycling rate of 10%, reduce nitrogen concentrations in waste water by 20% compared to the 2005 average, or improve the documentation of birdstrikes. Targets can be developed informally through brainstorming and staff knowledge, or through a more formal and structured process of scoring and ranking environmental impacts. The airport's policy statement may set environmental goals and objectives that will influence the targets. The targets are specific performance metrics that must be met in order for the airport to achieve the identified objectives.

Once the airport can identify the processes/procedures that have an environmental impact, an EMS can be designed to manage the processes. Using the information on aspects and targets

25 *Leopold, Luna B.; Clarke, Frank E.; Hanshaw, Bruce B.; Balsley, James R. (1971). A Procedure for Evaluating Environmental Impact. Geological Survey Circular 645. Washington: U.S. Geological Survey.*

described above, design a program to efficiently manage the various aspects and potential impacts. This management system will be a set of processes and procedures that include timelines, resources, roles and staff responsibilities, and other information that will help the airport accomplish the environmental targets and objectives. The EMS is a tool for the airport's management to specify the individuals responsible for specific actions, how communications will take place, the different levels of responsibility, as well as the documents and records that will be produced to report these actions. Ideally, the EMS would streamline the procedures necessary for managing environmental actions, satisfy any legal requirements associated with environmental aspects, and also be designed to improve the overall environmental performance of the airport. In the United States, airport sustainability initiatives are usually included in the EMS process so they can be managed and implemented.[26]

If you want to meet the ISO international standard there are specific requirements that must be part of the EMS, as listed in Table IV below.

ISO Requirements Summarized
1. Identification of external and internal topics that are relevant to achieve the intended results of the management system, including environmental impacts, and of the interested stakeholders, their expectations and binding requirements.
2. An environmental policy supported by senior management.
3. Defined resources, roles, responsibilities and authorities for environmental management.
4. The identification of risks and opportunities with the identification of environmental aspects that the organization may cause and all binding requirements (legal and others).
5. The development of objectives and targets, and their environmental management programs.
6. The development of resources, competence, training and awareness procedures.
7. A communication process of the EMS to all stakeholders and interested parties.
8. The development of documented information, including the records management procedure.
9. The development of operational control procedure.
10. The development of emergency preparedness and response procedures.
11. The development of procedures to monitor and measure operations that can have significant impact on the environment.
12. The development of procedures to evaluate the compliance of binding requirements.
13. A program for completing internal EMS audits.
14. The development of procedures for management review by senior management.
15. Procedures developed for the management of non-conformance, corrective actions and continuous improvement.
Adapted from the ISO 14001:2015 standard (www.iso.org)

Table IV - *EMS Requirements*

26 *Delaney, Elizabeth and Barbara Thomson, 2013, Environmental Management System Development Process: A Synthesis of Airport Practice. ACRP Synthesis 44, Transportation Research Board. U.S. National Academy of Sciences, Washington DC. (ACRP 2013, p. 12)*

7. IMPLEMENTATION

Once the EMS is developed and there is a system for carrying it out, the next step is implementing the process effectively. The ISO standards encourage using operational controls to achieve the needed level of environmental performance. An operational control is a mechanism that an airport applies to the activities, products, and services of the airport to meet the targeted level of environmental performance. An operational control is intended to prevent or reduce any negative environmental impact from occurring, and to ensure any positive environmental impact occurs or continues. Operational controls are applied to the airport activities and services with potential for significant environmental impacts, and will generally have criteria that specify the level or result the process should achieve. For example, operational controls could include standard procedures for storage and disposal of hazardous waste. In addition to procedures, operational controls could also be interventions in a process, or the addition of technologies like water flow monitors and motion sensors for lighting; by installing such controls, environmental impacts can be minimized. There may be a need to develop operational controls for service suppliers, tenants, and contractors of the airport as well.

A key piece of implementing the EMS, is clear understanding of roles and responsibilities for the various actions. The EMS should identify the airport organization or staff position to perform specific tasks. Ensure that when EMS actions are assigned to staff that person has adequate education, training, or experience to fulfill the assigned tasks competently. Development of EMS training is a good practice, and will be especially helpful when individuals move on and new staff take their place. The EMS may also cover emergency preparedness and response, similar to an emergency response plan, and include procedures regarding who would do what under emergency situations.

Employees should have robust systems for communicating both internally and externally about the activities associated with the EMS. Internal communication between employees of the airport organization is critical for the day-to-day operation of the airport, and that is the same for EMS processes. Likewise, effective implementation of EMS processes will require good external communications, either between airport staff who manage more than one airport, or with parties and organizations outside the airport.

Good management systems are supported by good documentation. The EMS process must include a document control system that ensures documents are readable, appropriate to the purpose, and readily available as needed. Current EMS documents may be in circulation as they are used to carry out processes. There should be a process of record management that makes sure paperwork is accurate, and that records of completed activities are distributed to the appropriate places or archived for future reference. Many organizations find it useful to have the EMS process contained within a single manual, and they may also use the manual to collect the required documentation[27].

The EMS process often results in heightened environmental awareness. A central tenant of the EMS process is continuous improvement. It is common for an airport to find after implementation of an EMS that they must add new processes, develop additional operational procedures, or refine the criteria for success.

9. PERFORMANCE EVALUATION AND AUDITING

Performance Evaluation

The performance evaluation of an airport's EMS should be assessed on a regular basis through monitoring, measuring, analysing and evaluating some of its elements, in order to ensure valid results and the overall effectiveness of the EMS. The airport has to determine in advance what needs to be monitored and measured, and establish appropriate methodology, criteria and performance

27 *Guide to the Implementation of ISO 14001 at Airports. Report produced by CSA International, Toronto, CA, P. 22.*

indicators to do so, alongside with the definition of a timeline when results are to be evaluated.[28]

It is important to retain the relevant documentation containing the performance evaluation as evidence and report both internally and externally the relevant environment performance evaluation[29]. This reinforces the transparency of the system. Compliance should also be evaluated on a timely fashion, defined in advance, by the airport. This gives the opportunity for the airport to understand its level of compliance and also to take any action, if needed.[30]

Auditing

Internal auditing of the EMS at determined intervals is a requirement for an airport to assess the organization's conformity with its own requirements and requirements from an International Standard, if this is the case. This Audit must also assess if the EMS is effectively implemented and maintained, and it is through the audit that legal compliance is monitored and problems are corrected. In order to perform this internal auditing, the airport must establish an internal auditing programme setting a framework defining frequency, methods, responsibilities, planning requirements and reporting. The following elements shall be defined by an internal auditing programme: specific criteria to be used and the scope of the audit; the proper selection of auditors to assure objectivity and impartiality; and ensuring that audit results are reported to relevant management. Table V below summarizes the Internal Auditing Programme main requirements. Changes affecting the airport, the environmental importance of the process and also the result of previous audits should also be taken into consideration[31].

Step 1 Considering environmental benefits, changes to the organization and previous audits
Step 2 Definition of audit criteria and scope
Step 3 Selection of auditors to ensure impartiality and objectivity
Step 4 Report of results to relevant management

Table V - *Internal Auditing Program check list*

9. LESSONS LEARNED

Airports have gained useful experience with the development and implementation of an EMS, and experienced benefits such as improved environmental performance, regulatory compliance and public relations. An EMS implementation, however, may also face some barriers. A study conducted by Airport Cooperative Research Program (ACRP)[32] led to some useful conclusions that are of relevance to this e-publication. They are reported here with a view to bringing the findings to a wider audience of professionals involved in EMS implementation at airports.

Lessons learned from the above mentioned exercise are helpful to provide guidance to airports that are interested in and/or in the process of implementing an EMS. For instance, it was highlighted that several departments, such as maintenance and operations should be directly connected with environment, in order to share responsibility and successfully implement the EMS. In addition, management support was recognized as an important facilitator to justify and actually acquire needed resources. On the other hand, barriers to implementation of an EMS were also identified, such as competing priorities inside the organization alongside insufficient human resource and line management resistance.

Most airports that engaged in the ACRP exercise considered the overall implementation of the EMS and the integration of the system into the organization as their major success while at the same time some airports also acknowledged some issues that they believed could be improved, such as the organization database system to facilitate implementation; the understanding of the ISO 14001 requirements; having a manager for the program; making the EMS a priority; and adequately sharing of responsibility for the system implementation. Finally, when questioned about their future plans, airports replied that they wanted to go beyond compliance, by improving the overall concept of sustainability. The latter has become already a trend in some advanced environmental performants airports which are looking for other additional tools to improve their environment management efficiency.

EMS Responsibilities	Need to engage different departments regarding their environmental responsibility
Management Support	This is necessary to acquire the needed resources for a successful EMS implementa
EMS Benefits	Improved environmental performance; improved regulatory compliance; environmental risk reduction, cost reduction, among others
Barriers to Implementation	Competing priorities inside the organization may represent a major barrier for implementation alongside insufficient human resources and line management resistance
Successes	The overall implementation of the EMS, and the integration of the system into the organization, are successes
Improvements/ What would you do differently	Improve the organization database system to facilitate implementation; improve understanding of the ISO 14001 requirements, have a manager for the program, making the EMS a priority; adequate sharing of responsibility for the system implementation
Future Plans	Go beyond compliance by improving the overall concept of sustainability

Table VI - Lessons learned

28 ***ISO 14001:2015*** *page 14.*
29 ***ISO 14001:2015*** *page 14.*
30 ***ISO 14001:2015*** *page 14.*
31 *ISO 14001:2015 page 15.*
32 *The ACRP has assessed lessons learned from 12 airports regarding: EMS responsibilities, management support, benefits, barriers to implementation, successes, improvements and future plans.The following text addressing lessons learned on the above mentioned topics is based on this ACRP study and on responses from 12 airports.*

10. LIST OF ACRONYMS

ACI Airports Council International

ACRP Airport Cooperative Research Program

CAEP Committee on Aviation Environmental Protection

EMS Environmental Management System

EMAS Eco-Management Audit Scheme

EPA Environment Protection Agency

ICAO International Civil Aviation Organization

IER Initial Environmental Review

ISO International Organization for Standardization

PDCA Plan, Do, Check, Act Principle

11. REFERENCES

ICAO - ICAO Doc 9184 Airport Planning Manual , Part 2

ICAO - ICAO Environmental Report 2016, http://www.icao.int/environmental-protection/Pages/ENV2016.aspx

ICAO - ICAO Doc 9968 Report on EMS practices in the aviation sector

CSA International - Guide to the Implementation of ISO 14001 at Airports

WBCSD - World Business Council for Sustainable Development , http://www.wbcsd.org/home.aspx

FAA - Implementation Guidance for Regional EMS

ACI PRP Handbook - Airport Council International: Policy and Recommended Practises Handbook (2009), http://www.aci.aero/About-ACI/Policies-Practices

SAGA Database - Sustainable Aviation Guidance Alliance: Database containing more than 900 sustainability initiatives, or 529 initiatives on environment; approximately 100 case studies are spelled out. http://www.airportsustainability.org/

TRB ACRP - Transport Research Board/Airport Cooperative Research Program: Synthesis 44: EMS development process- a synthesis of airport practices

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ENVIRONMENT

A Focus on the production of renewable energy at the Airport site

ECO AIRPORT TOOLKIT

INDEX

ICAO ENVIRONMENT

A Focus on the production of renewable energy at the Airport site

ECO AIRPORT TOOLKIT

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1. FOREWORD

The Paris Agreement, adopted in December 2015 has the central aim to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Individual countries or Parties will have to nationally determine their contribution to these targets, and all sectors of society will need to contribute. Decarbonising society is an essential element of this strategy. Renewable energy sources, such as solar photovoltaic panels, wind turbines, and geothermal systems, are pivotal to its success.

In addition to the carbon emissions reductions, renewable energy sources are often lower in emissions of other air pollutants that impact local air quality. Implementing a renewable energy strategy has other potential benefits for airports such as utility cost savings, a more reliable source of energy, and positive community engagement.

The primary audience for this document includes States, civil aviation authorities, and airports including tenants, particularly those without dedicated environmental departments or staff. This document is the first in a series of practical and ready-to-use information documents to support the planning and implementation of airport infrastructure projects that envisage significant environmental benefits. Each of these publications will provide a high-level overview and introduction to a specific topic related to environmental planning at airports, including an extensive list of resources where more in-depth information can be found. The documents are intended to be readily updated as new information becomes available and will be accessible from the ICAO Environment website as an e-collection.

What are some of the benefits of renewable energy for my airport?

- Produces fewer life-cycle emissions than fossil fuels.
- Can supplement the purchase of non-renewable energy.
- Can reduce operating costs.
- Can reduce your airport's carbon footprint.
- Can reduce uncertainty in power supply.
- Contributes to regulatory compliance.
- Offers potential for revenue generation.
- Offers potential local air quality benefit.
- Contributes toward climate resilience.

2. WHAT ARE RENEWABLE ENERGIES?

Renewable energy is defined as energy from a source that is not depleted when used. Solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy.

They differ from fossil fuels (i.e., petroleum, coal and natural gas), which result from the transformation of organisms over millions of years making them a non-renewable source of energy.

Renewable sources of energy are used to produce electricity, heating, cooling and to fuel various means of transportation. Electricity is essential for the operation of an airport, and renewable energy increases the options available to airports for their energy needs. Most airports in developed countries buy electricity from a power provider, making energy use a major operating cost for the airport. Ensuring energy is used efficiently is a basic cost control measure.

Renewable energy has additional benefits: it produces fewer emissions and reduces the environmental footprint[1]. In addition, installing renewable energy generation technologies on site at an airport can lower the carbon footprint without the construction of a large-scale power plant. For example, when sited correctly, solar panels on rooftops can supplement the purchased electricity with minimal impact to airport operations. How airports can make maximum use of renewable energy depends on the type of airport, the geographic location, and resources available. Not all energy sources have the same technical and operational characteristics. Therefore, depending on the end usage, the source of renewable energy or the energy mix will differ. In some cases, power providers will offer both renewable and non-renewable energy contracts for purchase.

Decisions for increased investments in renewable energy result from a combination of factors. One potential factor is the increased difficulty of production and price volatility of fossil fuels, whereas governments or private companies may decide to enhance their energy security and minimise their financial risks by reducing their dependence on fossil fuels. In States with growing energy needs, energy security is considered an essential element of future growth and prosperity.

In parallel, the carbon footprint of fossil fuels is also a strong incentive to move towards a more environmentally sustainable energy mix. Burning fossil fuels results in the release of greenhouse gases that contribute to climate change and results in the release of local air pollutants that deteriorate local air quality.

In addition, the average costs of wind and solar electricity, two major sources of renewable energy, have been significantly decreasing in recent years and could fall 59% by 2025, according to a study published in June 2016 by the International Renewable Energy Agency (IRENA). This change in costs could incentivize airport operators to invest in renewable energy sources[2].

Concerns about future energy supply, climate change and air quality are significant for airports. As key components of the global transportation infrastructure network, airports are similar to other public and private entities in their strategic demand for a stable and sustainable energy supply. To explore how airports can achieve this, the following section introduces the airport sector's energy uses.

Safety

Safety risk assessments should be performed, and operational impacts should be assessed before installation of any renewable energy source. For instance, "the Dutch Airline Pilots Association (ALPA) supports the use of renewable energy sources, considering that they operationally fit. However, they highlight that the design and installation should always be preceded by a risk analysis, specific for each installation." [3] On the same line, the British 'Honourable Company of Air Pilots' has also published practical information for pilots regarding windfarms effects on radars.[4]

1 Based on data collected from international airport Greenhouse Gas (GHG) inventories, building energy consumption is often one of the most significant sources of GHG emissions that is under the direct control of the airport.

2 http://www.irena.org/News/Description.aspx?NType=A&mnu=cat&PriMenuID=16&CatID=84&News_ID=1452

3. ENERGY USE AT AN AIRPORT: A SNAPSHOT

Airports are facilities similar to small or medium-sized cities. Accordingly, they need energy to operate their infrastructure and to provide their services. Airport systems have a high electrical energy demand due to unique requirements of airport buildings and facilities – such as terminal air conditioning, pre-conditioned air and power at gates, powering of many appliances, and other systems specific to airports such as baggage handling systems and airfield lighting. Airports are hubs of regional economic activity and are a critical link in regional transportation networks. Thus the safe, economic and most importantly, reliable provision of electricity at airports is of great importance.

Airports of all sizes must offer a minimum level of service requiring the use of energy to ensure the safe and efficient operation of flights. The most common energy uses at an airport are:

- Airport terminal: lighting, heating and cooling (air conditioning) and appliances (baggage handling systems, terminal bridges)

- Airport airside: runway lighting, auxiliary power units (APUs) and aircraft ground energy systems (AGES), ground vehicles (from airport operators, ground-handling companies and firefighting services) and airside facilities such as hangars.

An energy audit[5] can help an airport operator to understand its energy usage, and be strategic about investments into energy efficiency technologies. For example, if the boilers that heat water are a large source of energy consumption for an airport, then replacing that system with a geothermal or solar water heating system could be of a high priority to reduce operational costs. Alternatively, an airport operator may wish to list energy conservation measures that it would like to pursue (to achieve cost or emission savings), and make sure that airport staff and management work towards and support those goals. Once an airport operator understands its energy usage and where the best and most cost-effective opportunities for improvements are, the airport may consider investments in renewable energy projects.

4. THE RATIONALE FOR INVESTING IN RENEWABLE ENERGY

Renewable energy projects are known to provide multiple benefits for an individual airport in addition to the environmental benefits stretching beyond the airport site itself. Benefits of renewable energy projects may include:

Operational reliability and risk mitigation

Depending on project design and ownership structure, operational reliability may be enhanced as a consequence of more consistent energy flows, making shortages and adverse effects on operational

3 Solar Panel Installations at Airports. Dutch ALPA. Available at: https://www.vnv.nl/publications/solar-panel-installations-at-airports

4 Windfarms and the Practical Pilot. The Honourable Company of Air Pilots.

Useful websites: https://www.caa.co.uk/windfarms
https://www.nats.aero/serices/information/wind-farms/
https://www.gov.uk/mod-safeguarding
http://airspaacesafety.com

5 An energy audit is a study that indicates the largest uses of power at an airport, the origin of energies and energy transformations.

performance less likely to occur. If the renewable energy installation is owned or otherwise controlled by the airport, and the energy generated stays on-site (and is not dependant on an external electric grid), then it provides a risk mitigation measure to the airport and its wide range of users for whom a steady supply of energy is crucial.

If designed and developed with potential impacts from climate change are taken into account, renewable energy projects can increase the resiliency of an airport. A range of considerations should be taken into account when developing the airport's energy strategy and associated infrastructure, including:

- Potential for changing temperatures, which can affect airport infrastructure or the future energy needs of airports. That is, more extreme temperatures will either demand more cooling or more heating of airport buildings, and this is necessary to include in airport energy planning.
- More extreme weather such as higher levels of precipitation or increased storm surges, may be a concern for airports in many regions of the world.

Price volatility management

Price volatility of key commodities such as energy, can be a cause of frustration for any airport operator, particularly because airport operators have limited ability to predict or influence energy costs. In contrast, renewable energy generated on-airport is controlled by the airport and can be more predictable in terms of supply and cost.

Legislative and regulatory compliance

Some States may have legislative and regulatory compliance requirements that can be met or addressed with on-site renewable energy projects. By investing in a renewable energy supply, an airport may proactively address standards, policies and other compliance elements, whilst being at the forefront of the operating environment. Some States may also have regulatory incentives such as subsidies and tax-breaks for renewable energy that airport operators should consider.

Greenhouse gas (GHG) emissions reduction objectives

GHG emissions reduction objectives are goals for many airports around the world. Renewable energies such as solar and wind are free of direct emissions. By replacing all or a portion of the fossil fuels it uses, an airport can make significant progress towards its GHG emissions reduction goals[6].

Corporate Social Responsibility (CSR) reporting and stakeholder communications

CSR reporting and stakeholder communications concerning the airport's environmental footprint and broader community engagement will be enriched by commitments to renewable energy. These commitments can demonstrate environmental leadership and underscore it with tangible and effective actions.

Opportunities for additional revenue generation

In rare cases an airport may be able to generate revenue with the production of renewable energy that exceeds its own needs. If enough energy can be generated, airports could sell clean surplus energy production to the surrounding community. This can prove particularly advantageous if nearby communities have different consumption patterns than the airport, such as daytime versus night-time use patterns. Additionally, airports may choose to allow third parties to generate energy on their property through land lease or other arrangements.

6 *The Airport Carbon Emissions Reporting Tool, available free through the Airports Council International can assist an airport in calculating its GHG emissions*

5. WHICH RENEWABLE ENERGIES, WHERE?

Investments in renewable energies should be considered alongside broader environmental management. Renewables, in conjunction with a wide range of energy-efficiency improvements, can form a robust framework of measures aimed at further reducing operating costs and diminishing the airport's environmental footprint. Therefore it is useful to consider the use of renewable energies within the context of established standards such as ISO 14001 on environmental management systems and ISO 50001 on energy management, as these are widespread in the airport community already.

Even though constructing a renewable energy installation can reduce an airport's GHG emissions, those measures are typically not the easiest, quickest or most cost-effective options. Frequently, it is more expedient and economically feasible for an airport to implement energy conservation measures. These measures can be done quickly, and reduce its energy demand. Some examples of energy conservation measures can be found in the list below:

- Short-term operational changes
  - » Night-time shut down
  - » Demand response
- Long-term infrastructure improvements
  - » Replacing conventional lighting systems with LEDs
  - » HVAC upgrades
  - » Building insulation/sealing

After considering energy conservation measures the next step is an evaluation of the possibility of producing and using alternative sources of energy. Several renewable energy options exist for airports, including:

- Solar
- Wind
- Biomass
- Hydro
- Geothermal

Initially, it is worth stating that the above energy options and their practical application to the individual airport depends on the airport's inherent physical settings (e.g. geography, geology and climate), combined with operational and economic realities.

Solar

Among the more common and widely applicable renewable energy projects at airport sites are photovoltaic (PV) systems, which convert sunlight into electricity. PV systems have been installed at well over 100 airports worldwide and are well-suited for many existing airport designs due to the vast horizontal surfaces on which they can be installed. They can be mounted on terminal buildings or placed on unused or otherwise unproductive airport property. Some airports have even used the harnessed solar energy to power ground vehicles or to deploy charging stations for electric cars in parking areas.

PV systems that supply power for at-gate operations have furthermore been granted eligibility under the Clean Development Mechanism (CDM) framework. For developing States, a PV project can apply for CDM eligibility and, if approved, earn saleable Certified Emission Reduction (CER)

credits. These are worthy of consideration as possible financing elements for investing in PV systems for eligible States.

For many airports, PV systems constitute an economically and technically feasible way to increase the share of renewables in the energy supply. In some cases, however, PV systems may present challenges with regards to solar glare, and the airport must consider the operational safety implications for their specific location and proposed project[7].

Wind

Wind energy is another option for airports, but one that is still relatively novel in its application due to a number of technical barriers with respect to the safety of aircraft operations. Wind turbines, which transform the kinetic energy of the wind into electricity, are capable of meeting substantial electricity needs. Turbine installation and use necessitates extensive safety assessments, as they may be considered (alongside other tall objects) capable of penetrating the navigable airspace in close vicinity to airports and generate interference issues with safety critical communication, navigation and surveillance infrastructure. In light of this, alternative design options may be considered (e.g. wind turbines with vertical axes).

Biomass

Biomass energy is another option for airports depending on the availability of feedstock supply chains. Biomass is an organic material consisting of plant and animal-based residues typically from forestry and agriculture waste. Biomass can also be produced, but sustainability and ethical requirements need to be addressed. Biomass is converted into fuel offering a variety of applications at the airport site, including heating and cooling of terminal buildings and electricity generation.

The fact that biomass derives from a comprehensive (and progressive) list of materials makes it necessary for the individual airport operators identify the relevant sources that are most feasible to its operational and commercial context. For example, biomass waste at an airport can be transformed into energy for subsequent heating and cooling applications, while another airport can obtain energy from locally-sourced abundant resources such as wood waste (proper management of biomass is important to prevent issues related to wildlife management).

Hydro-power

Hydro-power is also a potential source of renewable energy at airports. The electricity is created in a process by which high water pressure forces a turbine to spin. The water flow can be controlled and electricity output altered to match the airport's needs. This option would require a location near a water source.

Geothermal

Finally, geothermal energy systems are diverse in terms of energy extraction methods and end-uses and are capable of heating and cooling airport buildings. For terminal heating and cooling, airports can pump low-temperature water from underground water tables for circulation in on-site air heating and cooling systems. If the water reservoir is boiling hot (usually in the very deep underground) the steam can be captured to drive a turbine for electricity generation. However, these options are highly contingent on the airport's geological conditions. The greater part of these systems are below the ground and therefore do not disrupt aeronautical operations (provided that the facility above ground is not blocking visual and navigational aids), though, they are often complex to install. Consequently, airport projects with geothermal energy are typically most worthwhile executing in combination with the construction of new facilities or a major refurbishment of existing airport structures.

7 *See Solar Panel Installations at Airports. Dutch ALPA. Available at: https://www.vnv.nl/publications/solar-panel-installations-at-airports*

Accessing renewable energies

The different types of potential renewable energy projects described in this document will have varying levels of complexity, economic feasibility and benefits for individual airports. It is clear from the brief outline of these options that launching a renewable energy project is a complex task. Renewable energy projects can have implications on core aeronautical operations, or may be impractical for financial and technical reasons. As a result the airport should consider all these perspectives before pursing changes to energy production and consumption within airport boundaries.

If development of an on-site renewable energy project is not financially or operationally feasible, an airport can buy alternative energy from off-site producers or their utility provider through a power purchase agreement or through the purchase of renewable energy credits, e.g. district heating from biomass or electricity from an adjacent wind farm. These considerations are also underscored by the degree to which energy storage is available for the different forms. It might therefore be useful for the airport to adopt a portfolio-based approach to fulfilling its energy needs and utilizing multiple sources of energy. These decisions will often be influenced by the airport's regulatory environment.

6. BEFORE YOU START

This section includes a range of elements to consider prior to launching a renewable energy project at an airport. First and foremost, it should be stated that safety concerns are absolutely paramount in any decision-making process. The costs, benefits and risks of each type of project should be fully considered and alternative design options may need to be explored.

Embarking upon an airport renewable energy project requires project management. It necessitates thorough planning and clear objectives from inception. Since airports are sophisticated self-contained communities with myriad stakeholders and operators, any project should clearly outline responsibilities of the individual agents along with the required action. In this process, it is critical that airports understand and comply with their regulatory requirements.

The environmental benefits that the project is expected to yield should be accounted for as accurately as possible and weighted against the economic costs involved, in order to assess the cost-effectiveness of the chosen measure(s). It is important that the project is viewed from a holistic perspective to detect any adverse impacts that may arise as a consequence of the measure. Finally, the project should consider practical matters such as a realistic timeframe and deadlines. For a more structured description of how an airport renewable energy project can be prepared, please consult Table 1 below.

Element	Content
Situation	States the baseline or the problem to be addressed.
Goals	Describes the energy initiative and the anticipated goals.
Responsibilities	Identifies who is responsible for the implementation (airport operator, concessionaire, external contractor).
Interfaces/partners	Describes which other partners are involved or need to be addressed.
Legal compliance	Confirms legal compliance or describes initiatives required to achieve it.
Airfield Safety	Assesses the impact on the safety at the airfield and confirms conformity.

Element	Content
Environmental benefits	Qualifies and quantifies the emissions reductions by this measure (GHG and local air pollutants).
Economic costs	Quantifies the costs associated with the implementation of the measure or combination of measures (investments and operating costs) under consideration and the relative cost-effectiveness of available options, noting that there could also be cost savings associated with the measure.
Interdependencies	Describes potential trade-offs or interdependencies (GHG emissions vs primary energy demand) and provides options to mitigate them.
Implementation	Gives some limited guidelines on how to implement the measure.
Time frame	Sets time frames or even deadlines for implementation.
Evaluation	Gives an evaluation of the measure and a recommendation for implementation.

Table I - *Structured description of measures (modified from the ICAO Doc 9889)*

7. RENEWABLE ENERGY CASE STUDIES

While the information presented in this document provides an overview of the reasons to consider renewable energy and the different types of renewable energies currently available, each airport's individual circumstances are unique, and States and individual airport operators will need to conduct an analysis of their specific situation to determine which projects are feasible and / or desirable.

To illustrate the range of different projects available, a series of case studies follows demonstrating a number of renewable energy initiatives from around the world. While these examples are specific to the locally available sources of energy produced and the regulatory environment in those specific locations, they provide an overview of considerations, costs and benefits, and lessons learned.

Key questions to consider as you review the case studies:

- What are the largest users of power at your airport? Consider an energy audit to identify them.
- What are your top energy conservation priorities? Don't consider renewable energy in isolation - consider a wider energy management framework.
- Who is responsible and who needs to be involved? Identify and engage the right stakeholders.
- What are your objectives? Do you want to generate your own or purchase renewable energy?
- Which renewable energy sources do you have access to implement or purchase?
- Which will work best for you? How expensive? Carry out a cost-benefit analysis.
- Will it work in practice? Carry out a safety assessment and project feasibility study.
- Are there any potential trade-offs, interdependencies or non-benefits?
- What is the timeline and deadlines?

Case studies can be found from the following airports:

- Aéroports de Paris
- Stockholm-Arlanda Airport
- Cochin International Airport
- Denver International Airport
- Galapagos Seymour Airport
- Austin-Bergstrom International Airport
- Portland International Jetport (Portland, Maine)
- San Diego International Airport:
- Vancouver International Airport

ANNEX I: AVAILABLE SOURCES OF INFORMATION

The global airport industry, along with many other industries or organizations have developed and published many materials with respect to renewable energy or the energy management at airports in general. A very short selection is displayed in the following table.

Title	Description
ICAO	ICAO Doc 9184 Airport Planning Manual , Part 2
ICAO	ICAO Environmental Report 2016 http://www.icao.int/environmental-protection/Pages/ENV2016.aspx
IEA	International Energy Agency http://www.iea.org/
IRENA	International Renewable Energy Agency http://www.irena.org/home/index.aspx?PriMenuID=12&mnu=PriPriMenuID=12&mnu=Pri
WBCSD	World Business Council for Sustainable Development http://www.wbcsd.org/home.aspx
Airport Carbon Accreditation	http://www.airportcarbonaccreditation.org/
ACI PRP Handbook	Airport Council International: Policy and Recommended Practices Handbook (2016) http://www.aci.aero/About-ACI/Policies-Practices
SAGA Database	Sustainable Aviation Guidance Alliance: Database containing more than 900 sustainability initiatives, or 529 initiatives on environment; approximately 100 case studies are spelled out. http://www.airportsustainability.org/
ADV	German Airport Association: Climate mitigation initiatives of German, Austrian and Swiss airports (2015) http://adv.aero/fachbereiche/umwelt/klimaschutz/ http://adv.aero/wp-content/uploads/2015/12/ADV_Klima_2015_Web.pdf
World Bank	World Bank Transport Papers: Air Transport and Energy Efficiency (TP-38, 2012) http://siteresources.worldbank.org/mwg-internal/de5fs23hu73ds/progress?id=2iHryE6UcaEvBz2bsXkQgzvqx9CQ2S4oI3DeQ1BLOGw
TRB ACRP	Transport Research Board/Airport Cooperative Research Program: Report 141 Renewable Energy as an Airport Revenue Source Report 151 Developing a Business Case for Renewable Energy at Airports

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1. INTRODUCTION

Every airport must manage waste, and implementing efficient and cost-effective waste management practices presents many challenges. There is a wide range of sustainable practices that can make the management of waste at airports more economic and better for the environment. Furthermore, successful airport waste management implementation has the potential to positively impact airport authorities, customers and the surrounding community at large.

Airports are local entities. Waste management at airports are therefore generally reliant on national/local regulation, drivers and realities. For instance, a municipality with waste reduction targets can influence an airport operator's waste management policy. Additionally, stakeholder's arrangements with the airport operator also vary from place to place (e.g. contracts, responsibilities) and may impact the ability of the airport operator to influence its stakeholders.

In this e-publication "Waste Management at Airports" general principles and approaches will be addressed. It will provide the basics of waste management at the airport site, including in particular environmentally friendly practices, and the new concept of circular economy, which can also minimize waste.

2. DEFINITION OF WASTE

For the purpose of this e-publication, waste will be considered as any type of "unwanted or unused" products/materials/substances that happen to be produced and/or arrive at the airport site and that needs to be given a proper treatment. Waste management, therefore, will be the process of handling the waste, which could come from aircraft (domestic/international), tenants, maintenance activities, aircraft and ground vehicles operations, offices, construction and so on, as well as dealing with the different requirements of these different types of waste.

However, in reality there is no single definition of waste, especially if one is trying to combine a common understanding of the different practices, regulations and levels of maturity of waste management, including environmentally sound performance around the globe. The Oxford dictionary defines waste, in general, as "Unwanted or unused material, substances and by-products"[1]. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal defines wastes as "substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law. It also defines what can be considered as an environmentally sound management of hazardous wastes or other wastes: practices that ensure that these wastes "are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes".

The majority of this document focuses on the extent to which the materials, substances, and by-products of the modern aviation system are waste and the choices airports have when deciding what to do with it.

For the aviation industry, two other considerations are of primary concern, 1) is the waste 'international,' and is it hazardous waste? States often have their own regulation defining specific treatment for international waste and airport operators must follow them. For example, the Canadian International Waste Directive defines International waste as any "waste removed from aircrafts … including things that are forfeited or voluntarily surrendered by international travelers arriving in Canada."[2] The Basel Convention deals with a specific type of international waste – hazardous, defining rules for waste that are explosive, flammable, toxic, corrosive or considered hazardous by their annexes or national laws of parties to the Convention.

1 *Oxford Dictionary. Online, available at: https://en.oxforddictionaries.com/definition/waste*

2 *Canadian International Waste Directive http://www.inspection.gc.ca/animals/terrestrial-animals/imports/policies/general/2002-17/eng/1321050654899/1323826743862*

This publication will provide the basics of waste management at the airport site, including in particular environmentally friendly practices, and the new concept of circular economy which can also minimize waste and give them a business model where they would be treated in a different fashion, challenging some definitions discussed above. Generally, hazardous waste falls into the category of "required by law wastes," and there are specific procedures for handling and disposal of this waste. Consequently, it is not discussed in detail in this paper.

3. TYPES OF WASTE

In practice, airport operations encounter various types of waste, including: Municipal Solid Waste (MSW); Construction and Demolition Debris (CDD); waste from aircraft flights (deplaned waste); compostable waste; hazardous and industrial waste; and lavatory waste. For MSW and CDD, airports have choices in how to manage collection, treatment, storage, and disposal. Those choices, when considered and carried out in beneficial ways, can improve airport operations and minimize environmental impacts

3.1 MUNICIPAL SOLID WASTE (MSW)

This is the type of waste that airports have the most choice in managing. MSW is made up of everyday items that are used and discarded, such as aluminum and steel cans, glass bottles and containers, plastic bottles and containers, packaging bags, paper products, and cardboard. Airport MSW comes from four primary sources as follows:

1. Terminal waste – from public areas and airport administrative offices;
2. Tenant waste – from terminal retail and concessions;
3. Airline waste – from airplanes and airline offices; and
4. Cargo waste – from cargo operations

3.2 CONSTRUCTION AND DEMOLITION DEBRIS (CDD)[3]

Another common type of waste at airports is Construction and Demolition Debris (CDD). CDD can come from land clearing, excavation, or – as the name implies – construction and demolition at the airport. CDD may include such materials as concrete, wood, metals, soil, bricks and masonry material, asphalt, rock, stone, gravel, and sand, roofing materials, drywall, carpet, plastic, pipe, and others.[4]

3.3 WASTE FROM AIRCRAFT FLIGHTS (DEPLANED WASTE)

Waste from airplanes (deplaned waste) is a specific type of MSW that is removed from passenger aircraft. Almost 20% of an airport's total MSW comes from deplaned waste after flights.[5] Deplaned waste includes "galley waste" – materials typically collected by airline caterers as part of the de-catering process, including compactor boxes, waste carts (bags), food carts, and bonded carts – which may be subject to more rigorous disposal methods.

3.4 INTERNATIONAL WASTE

Special attention has to be made for international waste. This is generally waste from international flights, but also can include the waste from the terminals that international flights service. When waste originates from countries with different policies and regulations, there is a risk of introduction of plant pests, diseases, and other contaminants. For these reasons, this waste is sometimes called quarantined waste (QW). Although international waste is often similar in material type to MSW, airports generally handle and process international waste separately from other waste types. In many cases international waste is incinerated on-site, or the airport arranges for it to be packaged and sent for disposal.

3.5 COMPOSTABLE AND BIODEGRADABLE WASTE

Airports generate waste that is biodegradable. Food waste from terminals: food that is not consumed, or waste generated during food preparation is one of these. Airport landscaping activities also generate green waste – trees, shrubs, and grass clippings, leaves, and similar vegetation generated by landscape maintenance. These types of organic wastes can be composted, but airports are now developing other creative means of disposal. These types of wastes can also be categorized as MSW, although these often have different treatment options than MSW.

3.6 HAZARDOUS AND INDUSTRIAL WASTE

These types of waste products consist of oils, solvents, and other chemical waste from activities such as aircraft and ground vehicle washing and cleaning, fueling operations, aircraft maintenance and repair including painting and metalwork, engine test cell operations, de/anti-icing operations, ground vehicle maintenance, and abandoned aircraft. These types of wastes tend to be closely regulated by state law, and require special treatment, storage, and disposal, and therefore this document does not address hazardous and industrial waste management.

3.7 LAVATORY WASTE

Lavatory waste is considered as a special type of waste and contains chemicals and potential enteric pathogens and can present risks to the environment and human health if not handled properly. Caution must be taken to ensure that releases of lavatory waste do not occur[6].

4. WASTE MANAGEMENT PRINCIPLES

Airport Council International's (ACI) Policy and Recommended Practices Handbook[7] provides guiding principles for waste management at airports; "Airports should promote the culture of avoiding solid waste generation and, where possible, extracting value from remaining waste with the ultimate goal of sending zero waste to landfills."

4.1 WASTE HIERARCHY

The ACI Policy Handbook provides a waste decision hierarchy, that shows – in order of decreasing priority – what constitutes the best overall environmental waste management choices: to avoid; to reduce; to reuse; to recycle; and finally, to dispose with the ultimate goal of eliminating waste going to landfills. By this decision hierarchy, the first consideration should be given to minimize the generation of waste at the

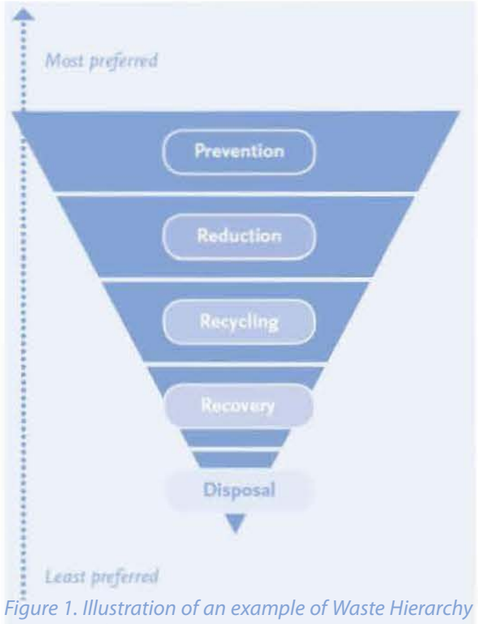

Figure 1. Illustration of an example of Waste Hierarchy from United Nations Environment Programme (UNEP)

3 *Note: there are various ways of referring to construction and demolition waste, as well as differing acronyms: CDD, C&D, CDW, CRD, etc*
4 *Adapted from: Guidance on Airport Recycling, Reuse, and Waste Reduction Plans. Memo from the Federal Aviation Administration September 30, 2014.*
5 *ibid*
6 *Ibid*
7 *ACI, ACI Policy and Recommended Practices Handbook (8th edition) 2016*

airport, and additionally, include opportunities for cost savings through improved management of waste, the feasibility of waste recycling at the airport, and the potential for generation of revenue from airport waste.

EU Directive (2008/98/EC) also describes a priority order of waste prevention and management legislation and policy options: prevention; preparing for re-use; recycling; other recovery; and disposal[8]. The directive recognizes that "waste hierarchy generally lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy", however sometimes it could be justified to depart from such hierarchy in order to address specific waste streams that would require correlating needs of technical feasibility, economic viability and environmental protection[9].

Waste hierarchy can differ in their nomenclature, however the main objective is achieved if one understands that the most important principle is to try to reduce waste to the minimal extent possible[10].

4.2 WASTE AVOIDANCE

Waste avoidance should be at the top of any waste management hierarchy, as it is in the ACI and EC policies on waste management (see figure 1). Waste avoidance refers to the measures to be implemented before a substance becomes waste.

4.3 WASTE REDUCTION

Reducing waste can contribute to airport sustainability and to cost savings. Some reduction efforts may include more economical use of materials, while some may divert to another process such as recycling. All processing of waste requires effort and energy, but by extension, any activity that might contribute to reducing the amounts of waste also decreases transportation emissions and energy necessary to process it.

4.4 WASTE REUSE

Airports may reuse and repurpose materials by using contractual requirements with tenants to require waste minimization activities, such as use of specific materials, cleaners, or paints. The reuse or repurposing of recovered materials also reduces the demand for new materials, for example reducing mining of aluminum ore.

4.5 WASTE RECYCLING

A common way to reduce the amount of waste is to establish a recycling program. Approximately 75 percent of the waste stream at airports is recyclable or compostable, with paper being the largest single category of MSW generated by the airline industry[11]. With recycling, residual waste is reduced and energy and materials are recaptured.

There are two types of recycling found at airports that correspond to the two types of waste – MSW and CDD. MSW recycling can offer cost savings, but requires development and implementation of an effective recycling process by the airport, which will pose costs as well. CDD recycling can be a large source of savings in terms of materials and cost, but requires careful planning to realize those savings.

8 E.U Directive (2008/98/EC). Available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

9 Ibid

10 UNEP (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. Available at: http://cwm.unitar.org/national-profiles/publications/cw/wm/UNEP_UNITAR_NWMS_English.pdf
Different versions of the hierarchy have been adopted by different countries, although they are all broadly similar to that outlined above.

11 Hershkowitz, Allen and Darby Hoover, 2006, Trash Landings: How Airlines and Airports Can Clean Up Their Recycling Programs. A report by the Natural Resources Defense Council.

4.5.1 MSW RECYCLING

Recycling airport MSW can offer economic and operational savings. It will likely require training of staff, placement of special containers throughout the airport to collect recyclables, and procedures for sorting and shipping the recycled materials to the correct destinations. For a recycling effort to be successful, management support will be essential. The person leading the effort will have to coordinate with every sector of the airport to develop a process that works best. Strong leadership will result in a better process.

4.5.2 CDD RECYCLING

CDD from airport construction projects brings different considerations than MSW. A key consideration for airports is recycling of materials such as concrete and asphalt pavements, masonry, rocks and gravel, wood, and piping, generated during construction, demolition, renovation, maintenance, and repairs. Some of these materials can be reused on-site, while others may have a reuse within the community, thus contributing benefits locally. CDD recycling can have the following benefits:

- Economic – Provides cost savings from reduced material hauling, disposal fees, and fuel costs, and avoiding purchasing new materials. Construction recycling creates employment and economic activity that benefits local economies.
- Environmental – Reduces the amount of materials sent to landfills and the environmental impacts of extracting or producing new materials. The reuse of materials on-site reduces off-site hauling, and decreases transportation air emissions and fuel burn.
- Operational – Streamlines the quantification and organization of materials on-site, reducing impacts to airport operations. Less time and labor may be needed for hauling, installation and maintenance.
- Social – Reduces traffic in the surrounding community through reduced off-site hauling[12].

4.6 WASTE TO ENERGY

Waste recovery embraces the conversion of non-recyclable waste materials into more useful kinds of fuel that can be used to supply energy. This process is known as "waste to energy". The conversion of waste to energy can be in the form of heat, electricity, or fuel through several processes such as: combustion (incineration), anaerobic digestion, gasification and landfill gas recovery. The conversion of non-recyclable waste materials into energy generates a relatively clean source of energy compared to conventional (fossil fuel) sources by offsetting the need for conventional sources for energy and in that way reduces the total carbon emissions.

4.7 WASTE DISPOSAL

Ultimately, some airport waste must be disposed of. While waste management decisions such as reducing and reusing materials aim to minimize waste and recapture materials and energy, at the time of this writing, this is not always feasible. The landfill or incinerator are often the choice for airport waste that cannot be handled in other ways. In some cases the landfill utilities themselves are engaged in the process of 'waste-to-energy' recapture through incineration or other processes.

12 From Recycling, Reuse and Waste Reduction at Airports: A Synthesis Document. Report prepared by the U.S. Federal Aviation Administration, 2013, page 18.

5 WASTE MANAGEMENT APPROACH - GOALS, ORGANIZATION AND RESPONSIBILITIES

Minimizing overall waste throughout airports' operation and value chain entails not only maximizing the amount of reused and recycled items from waste, but also the consideration of social, economic, environmental, and operational aspects of waste in the broader context of airport management. It is imperative to engage airport management and ensure their commitment, define clear roles and responsibilities of stakeholders involved as well as share overall objectives.

5.1 WASTE AUDIT

A waste audit is a study that characterizes the types of airport wastes, where they come from and where they end up. The audit should also specify amounts of waste and identify new opportunities for recycling, reuse, and waste reduction, and help evaluate the effectiveness of waste management over time. Carrying out a waste audit is an important first step in developing or refining a waste management plan. In particular, such information is crucial to developing a recycling program. A waste audit can reveal a lot about the patterns of people in the facility as well as their use and distribution of everyday items throughout the facilities and grounds. This would however require specific knowledge of airport operations and applicable regulations, as the situations that each airport faces are unique and highly dependent on its geographical and social condition.

5.2 WASTE MANAGEMENT AND REDUCTION PLAN

Using the waste audit, or other information on waste patterns within your airport, a plan should be designed for airport waste avoidance, reduction, reuse and recycling. Having a clear policy established by top management and in accordance with the national/regional regulatory framework is essential. Although the contents and scope of the plan will vary depending on the airport and its setting, in general practice, it should include goals and objectives of the waste management, list of essential stakeholders, characteristics of waste at the airport, waste reduction strategies to be implemented, and the description of the facility and its current waste processes.

The Waste Management implementation process should be described and documented within the airports standard procedures and operations. Although the level of details may vary according to the size of the airport, the principles should remain consistent, for example: Separation, Collection and Transportation. This plan may be included as part of a Master Plan for airport development, or as a component of an airport sustainability plan.

Plans to foster engagement with employees, managers, and contractors can also be included in the plan. Annex 1[13] provides a sample outline for an airport Recycling and Waste Reduction Plan.

5.3 IMPLEMENTATION

The successful implementation of a Waste Management Plan depends on different aspects that can influence its implementation. This should be part of a corporate strategy that should include coordination with all airport stakeholders, as they may be responsible for implementation within the area under their control. This policy should be reviewed periodically, and protocol adapted accordingly. Identifying economic incentives for reducing, reusing and recycling waste, and using these economic instruments to implement a cost-effective waste management approach are important elements to define the best implementation practices according to the airport local/regional characteristics. For instance, in some regions, it may be cheaper for the airport to directly get involved with all elements of separation, collection and transportation, while other may need to sub-contract.

Staff, tenants and passenger education campaigns should be included during the implementation program, in coordination with an implementation communication strategy, addressing both internal and external stakeholders. The airport website can be used as a vehicle for such communications, but other means to reach out to local communities should also be considered. Airports occupying premises in joint ownership with or employing workers from other organizations must establish effective means of consultation between the various interested parties over common problems of waste management. The benefits of implementing the waste management procedures are to be made public and to be sufficient motivator for employees to adopt the standard in its management system and daily operation.

5.4 MONITORING AND EVALUATION

A comprehensive monitoring and evaluation system should be implemented, for the airport operator to properly assess progress towards meeting the targets in the Waste Management strategy. Although the procedure may vary according to the level of details, the principles should remain consistent and compliant to other requirements applicable to the organization. Identifying common elements used in other areas of responsibility of the airport operator could help identifying the approach taken by the organization to monitor and evaluate operations. That should also be used, when appropriate to waste management. The foundation of a monitoring system could include but are not be limited to:

- Consistently measure and report waste data
- Collect data where required for assessing progress toward meeting targets
- The foundation of the evaluation could include, but are not be limited to:
- Easily Identifiable Key Performance Indicators (KPIs)
- KPIs should be able to be amended, if not accurate

13 *Annexes to this publication will be available soon.*

The proposed monitoring and evaluation system is to be based on several key information sources, as identified by airports and is to be continually maintained.

5.5 METRICS

Metrics are used to assess current situation, review policy and targets, and communicate results. Indicators using numeric value can facilitate the interpretation of the status and communication of results to both experts and non-expert audience. Indicators can also be used to benchmark progress over the years and compare results with other similar airports[14].

Common metrics used are weight and rate of different types of waste generated and diverted from landfill. (e.g. kg/tons of recycling; % of diversion). The metrics should be able to estimate the quantity and composition of waste generated. The United States Environmental Protection Agency (EPA) uses standard volume to weight conversion factors from Great Forest to assist with the conversion from volume to weight[15]. Costs can also be used as a metric, since planning for investment and return can also depend on the ability of to demonstrate cost-savings. EPA also provides guidance for organizations to estimate these cost-savings by defining waste removal costs as a baseline.

5.6 RISKS AND OPPORTUNITIES

The goal of the risk assessment process is to achieve acceptable risk through actions that would reduce the risks with considerations given to cost, feasibility and framework. These elements should be revised periodically.

Waste management risks are related to contamination. For instance, airports must have a proper waste management system in place to avoid contamination of airport sites and also to prevent the attraction of wildlife that could negatively impact the safety of operations. Contamination can also compromise recycling rates, as they can easily be reduced if recycling is mixed with organic material, for example.

Waste Management can also introduce new practices that could provide several opportunities, including: reducing costs, increasing recycling rates, improving the sustainable image of the airport, providing a better outreach to the communities and even positively influencing social related activities in the region.

A risks and opportunities assessment review should be an integral part of reviewing and balancing the suitability, adequacy, and effectiveness of the Waste Management System. The outcome of the Risks and Opportunities of the Waste Management system is to be compiled with the general system of Risks and Opportunities of the airport. The results of the risks and opportunities assessments are significant aspects that can be addressed by the organization through actions such as coordinating with different departments regarding possible impacts, setting an objective and waste management improvement program[16].

6 IMPLEMENTING A WASTE MANAGEMENT PROGRAM

6.1 STAKEHOLDER ENGAGEMENT AND EDUCATION (COMMUNICATIONS)

All waste reduction efforts require good communications and outreach efforts among airport stakeholders. Airports may publish highlights, data and metrics of their achievements and efforts. Such communication activity will foster motivation of relevant stakeholders, and also demonstrate the airports' commitment to sustainable business practices and corporate responsibility, leading to a more positive media coverage and public relations with the surrounding community.

Essential Stakeholders[17]

- Passengers passing through public areas, parking lots, garages, curbside pickup and drop off areas, restrooms, holding areas, and food courts
- Tenants such as businesses, airlines, and concessions (including taxi, hotel, rental cars, flight kitchens, and other industries that operate at the airport)
- Airline employees (including ground crew, cabin cleaning crew, catering);
- Employees of airport authorities, government offices, business agencies, etc.
- Maintenance operations and support facilities
- Contractors of the airport and its tenants, including aircraft cleaning and service, janitorial services, waste haulers, and construction contractors
- City or County solid waste management.

6.2 WASTE SURVEYS, AUDITS, STATISTICS WITH PROPER METRICS[18]

Before you develop a recycling plan, understand what waste is generated and collected at your airport by performing a waste assessment. A waste assessment provides qualitative and quantitative data. It also provides a baseline to measure progress in the future.

A waste assessment will help you answer the following questions:

- What areas of the airport generate waste?
- What recyclable material is generated?
- What type of waste is generated in each area of the airport?
- How much waste is generated by each area of the airport (airlines, airport offices, customers, concessions, etc)?
- What are the waste-related costs for trash and recycling containers, hauling, disposal recycling and labor (in equipment dollars and worker time)?

There are three primary approaches to conducting a waste assessment:

- Records Examination
- Facility Walk-Through
- Waste Sort

The type of assessment you choose is based on the size of your airport, the existing knowledge of your waste stream, the goals of the program, and the resources available.

14 https://www.iges.or.jp/en/archive/wmr/pdf/activity20121213/1-3_Visu_WM.pdf
15 https://www.epa.gov/sites/production/files/2016-03/documents/conversions.pdf
16 https://www.epa.gov/sites/production/files/2016-03/documents/estimate.pdf

17 https://www.faa.gov/airports/resources/publications/reports/environmental/media/RecyclingSynthesis2013.pdf
18 *Content draws largely from: EPA Developing and Implementing an Airport Recycling Program (2009) (I like this document quite a bit). Also used parts from: FAA Recycling, Reuse and Waste Reduction at Airports (2013), .FAA Memo - Guidance on Airport Recycling, Reuse, and Waste Reduction Plans (2014)*

Records Examination

A records examination provides information on the quantity of waste generated, as well as costs, for labor, equipment and services. If you don't have a centralized waste management system, try to compile all the waste data from the different haulers that service your airport. The records that may be useful include:

- purchasing, inventory, maintenance, and operating logs;
- supply and equipment invoices; and,
- waste hauling and disposal records and contracts.

Facility Walk-Through

A facility walk-through provides qualitative waste information through observation of staff and customers. The primary benefit of a facility walk-through is the first-hand observation of waste handling practices. The types and amounts of waste generated at the facility can be observed at this time. Track how waste moves through the airport. Assess existing space and equipment available for storage of waste, processing of recyclables, and other collection tasks. Also, talk to staff about their waste generation and disposal habits. The custodial staff is an excellent source of information in a facility walk-through.

Waste Audit

The most comprehensive and resource intensive waste assessment is a waste sort or "audit". A waste audit looks at the contents of waste receptacles throughout the airport to evaluate what and where material is disposed. Waste audits should include all areas under direct control of the airport and, when applicable, areas over which the airport has influence (tenants including: food services, retailers, car rental agencies, etc). Waste audits should include:

- Identification of what can and cannot be recycled in the region.
- Locations in the airport that generate waste.
- Types of wastes generated in each area, such as paper, scrap metal, plastic, etc.
- Identification of which materials that can be reduced, reused, and recycled
- Quantity of waste generated by each area of the airport (airlines, administrative offices, enplaned and deplaned passengers, concessions, etc.).
- Commodity rates for recyclable materials.
- Expenses for processing recyclables
- Costs for hauling, disposal and labor of landfill bound waste.

Waste Assessment Approaches

Strengths	Limitations
Records Examination	
• Provides weights and volumes of waste generated • Tracks major potential waste from the point of origin • Identifies the expensive or valuable components of an organization's waste • Documents financial benefits of reuse and recycling including total revenues and avoided disposal costs • Requires the least time and effort • Establishes baseline for metrics	• Lack of quantitative data for specific waste components • Does not provide qualitative data on how or why wastes are generated • Substantial effort necessary to collect and analyze data
Facility Walk-Through	
• Requires less time and effort than waste sorts • Allows first-hand examination of facility operations • Provides qualitative information about major waste components and waste-generating processes • Reveals waste reduction activities • Develops appreciation of logistics and obstacles tenants encounter in their efforts to recycle	• Limited identification of wastes generated • Multiple attempts may be necessary for comprehensive evaluation • Relies on estimates of waste generation
Waste Sort	
• Provides quantitative data on total waste generation and specific waste components • Allows problem solving and design of recycling program to be site specific	• Requires more time and effort than other approaches • Multiple attempts may be necessary for comprehensive evaluation • Does not provide qualitative data on how or why wastes are generated

Source: USEPA, Business Guide for Reducing Solid Waste, 1993.

Waste information provides baseline information that can be used to identify recycling, reuse, and waste reduction opportunities and priorities, and gauge program effectiveness over time. The simplest and most easily understood waste metric is the diversion rate (or % diversion). The diversion rate is the total weight of recyclable material that is "diverted" from the material that is disposed of as garbage.

It is calculated as:

$$\text{The diversion rate (\%)} = \frac{\text{weight of recyclable materials}}{\text{weight of recyclable materials + weight of garbage}} \times 100$$

6.3 WASTE INFRASTRUCTURE WITH SIGNAGE (COLORS, ICONS, TERMS)

The use of consistent waste signage (colors, icons and terms) helps the user to quickly identify and sort their recycling, which in turn, can assist with reducing contamination and increasing recycling rates[19].

The color and general signage should be easily identifiable by airport passengers, other stakeholders and staff. A common challenge that international passengers (and maybe domestic passengers too) face are different colors, icons and terms used by different airports, due to local regulation and culture. The lack of international waste signage standards is therefore a challenge for airports receiving international passengers and should be considered when designing signage. For instance, the use of icons can be considered user friendly, independent of the language of the passenger, if they are able to successfully pass the message to the end user in terms of quickly sorting their waste.

Another important element for the airport operator to consider is an assessment of passenger behavior, to better identify cultural behavior that could be addressed by an improved signage. Defining the most common items purchased at the airport and cross-checking if the waste bins can properly fit them is a simple exercise that can be helpful to increase recycling rates.

Finally, the airport operator should try to be consistent with both signage and education for all stakeholders and all facilities and points of collection and delivery at the airport.

6.4 ECONOMICS: INTRODUCTION OF "POLLUTER-PAYS-PRINCIPLE"

The Polluter Pays Principal was first established by the OECD in 1972 and is defined as:

"The polluter-pays principle is the principle according to which the polluter should bear the cost of measures to reduce pollution according to the extent of either the damage done to society or the exceeding of an acceptable level (standard) of pollution." (ref 1)

The principle is that environmental costs should be internalized by the producer of environmental damages, in other words that the costs of goods and services should incorporate the costs of pollution incurred during production and consumption. Many international declarations and regimes have now incorporated the polluter pays principal, for example the Helsinki Convention on the Marine Environment which states that contracting parties shall apply the polluter pays principal and the Rio Declaration which requires National authorities to promote the internalization of environmental costs on the basis that the polluter should bear the cost of pollution.

7. WASTE RECYCLING: DEVELOPMENT AND DESCRIPTION OF THE PROCESS

Recycling is the process of taking materials that have been discarded and reprocessing them into something new. The two main categories of airport waste, MSW and CDD, can be readily recycled, and airport waste management plans will generally include plans for how to collect and manage recycling materials at the airport. However, each type of waste has different recycling considerations that relate to the types of materials involved, how those materials are to be recycled, and the processes that go along with that.

7.1 MSW RECYCLING

19 http://www.metrovancouver.org/services/solid-waste/recycling-signage-campaigns/recycling-signage-colours/Pages/default.aspx

MSW recycling involves items like cans, bottles, and cardboard. The materials they are comprised of – aluminum, glass, and paper pulp – can generally be reprocessed into new materials. Recycling has many environmental benefits, including conservation of energy, lower greenhouse gas emissions, and reducing the need for landfills and incineration. A study from the United States found that aluminum accounts for only 1 percent of the air travel industry's waste stream, however the energy and emissions reduction benefits of recycling aluminum are disproportionately large; the energy benefits of recycling one ton of aluminum are 11 times that of recycling one ton of newspaper and eight times that of recycling the same amount of plastics[20].

This requires collecting of materials, and getting it to the right destination. In busy urban areas trash collectors will collect this type of 'recycling' separate from other trash. In some cases these different materials must be sorted into separate bins, and sent to different places for recycling. However, it is now common to see 'single stream' recycling in which cans, bottles and paper products can all be collected and sent off together.

Recycling of MSW is common at large airports. How the MSW recycling process is organized and managed is generally dependent on what systems are available to the airport for recycling. Considerations for MSW recycling may include state or local policies, logistical considerations such as space for trash compactors, contract issues with both staff and tenants, costs such as 'tipping' fees (the cost to dump a load of material at a facility), and operational requirements. The management of a recycling process involves collections of waste items in bins, and getting the materials to the right disposal points. If the local trash hauler accepts single stream recycling, the process is simplified somewhat. The airport can have bins for recyclables, and a second type for all other waste. Generally airports pair waste collection bins with recycling bins around the airport. The bins can be marked with images that show what should go in them, making it easier for travelers to know what goes where. In some cases bins are color coded to indicate what they accept, however there is no standard for use of colors so this can sometimes be confusing. If single stream recycling is not available from your waste hauler and recycling must be sorted, then more bins are necessary for the different types of recyclable materials to be collected. Additionally, the bags of recyclable materials must be gathered and staged according to material type for the waste hauler to collect.

Some of the challenges of airport recycling include decentralized waste management practices, recycling of airplane waste, and motivating tenants to recycle. Airports may have tenants arrange their own waste disposal, but MSW recycling works best when an airport centralizes all waste for disposal for the entire airport. While a centralized system requires more coordination with airlines and tenants, and more waste handled, it also offers efficiencies of scale such as lower hauling fees for larger loads. If waste is managed separately, then each system would need to include recycling. In terms of incentives to encourage recycling, some airports have offered prizes or recognition for the tenants who recycle the most. Establishing a recycling program may have costs for purchasing bins, as well as the labor costs to empty them. Depending on the hauling fees, the system could be an economic saving for the airport, but certainly have environmental benefits.

7.2 CDD RECYCLING

Airports can realize substantial financial savings from CDD recycling. Much of the cost savings come from reusing materials such as asphalt, concrete, and rebar onsite. The process for managing CDD recycling is very different from that of MSW. Construction usually involves contractors, and developing an effective CDD recycling process requires early planning to engage contractors in the process. Prior to undertaking a development project, airports need to consider the CDD recycling goals they would like to achieve from the process. In many cases this means establishing standards and/or specifications, and making sure these are included in the 'requests for proposal' as well as subsequent contracts for work.

20 *Hershkowitz, Allen and Darby Hoover, 2006, Trash Landings: How Airlines and Airports Can Clean Up Their Recycling Programs. A report by the Natural Resources Defense Council. p. V.*

Working with the construction contractor to develop a Construction Waste Management (CWM) plan is one way to be clear about expectations for reuse and recycling of CDD during a project. CDD recycling goals can also be integrated into an airport's Environmental Management System or sustainability plan to help track and manage them effectively. A CWM plan should identify the types and quantities of materials to be diverted from disposal, as well as the processes to be used to transport, store, and sort materials during the project. The plan should also consider how 'earthworks' associated with the construction, such as soils and cleared vegetation, will be handled.

A good CWM plan will help track the reuse of materials and may assist – when necessary – with reporting on material reuse or disposition. Training workshops for contractors, subcontractors and airport employees can help clarify expectations and roles among the project participants. Incentives can be designed into contracts to encourage reuse and recycling, and potentially offer a financial bonus when goals are met or exceeded. When materials can't be reused onsite, it may be possible to donate them to a charitable organization for reuse. Donation will not only minimize wastes but benefit others in the community.

When new materials must be procured, the airport and its contractors should consider replacing materials with recycled materials. For example, concrete, steel rebar and copper wire are products available with high-recycled content. Recycling concrete offers the largest potential volume on recycled materials.

Other factors that can affect the ability to recycle CDD may include state or local policies, and logistical considerations such as staging areas for materials, and locations to dispose of soils or other material types.

Existing waste management contracts and costs should be considered, in comparison with the tenant leases and contracts, potential cost of landfilling waste, and potential recycling and reuse costs. Commodity prices for the recycled materials, as well as costs for hauling, processing, and disposing of materials need to be taken into consideration. Understanding local and regional recycling services available in the area is also important as any airport recycling process will have to work with the collection systems available in the area.

7.3 ORGANIC WASTE: DESCRIPTION OF VARIOUS PROCESSING ROUTES

Organic waste, such as food and green waste, can be used as a resource in several processes. There are several processes for the recycling of organic waste, some of them are composting, anaerobic fermentation, and biorefinery.

- **Composting:** Organic waste often can be composted for use as fertilizer or soil improvement. This can be outsourced or executed in-house in a compost facility on the airport.
- **Anaerobic Fermentation:** Organic waste can also serve to produce biogas through the process of anaerobic fermentation. This process leads to the production of biogas and a digestate (a wet residue), which could be used as fertilizer (for more info: https://www.wur.nl/en/show/Anaerobic-fermentation.htm)
- **Biorefinery:** Another use for organic waste is as a source to produce bio-based products. Through chemical extraction processes valuable components can be extracted from organic for use in pharma, cosmetics or chemical industries. For example, soaps can be made from orange peels.

8. RESIDUAL WASTE (WHAT'S LEFT?)

While the best environmental objective is to minimize the amount of waste sent to landfills and incinerators, the fact remains that materials cannot always be recycled and airports cannot always implement waste management principles to the maximum efficiency. The residual airport waste is sent to landfills and incinerators. Both landfill and incineration often require pre-treatment and may pose a number of environmental threats and risks, from emissions of gaseous pollutants to infections. Therefore, disposal should be the last renders of resort in waste management practice for airports. Waste should only be disposed of in landfill when no other options are available.

8.1 LANDFILL AND INCINERATION

While waste can be shipped to landfills and incinerators, some airports prefer to manage waste by having these facilities on site. A landfill is an area of land, sometimes graded or otherwise prepared, where waste is disposed of. Landfills are a common means of disposing of waste, however, it is generally believed that landfills attract birds. Landfills in the proximity of airports can increase the risk of collisions between aircraft and birds. Having a landfill on site can be advantageous and cost effective in some circumstances, but the potential for wildlife collisions must be considered. Airport operators considering establishment of a landfill on or near their airport should conduct a wildlife hazard assessment to understand the wildlife in the area and minimize the risk of collision with aircraft.

Some airports have incinerators to dispose of waste. As with landfills, incinerators are one of the least desirable choices for waste management. Nevertheless, they have their role in disposing of airport waste. In many states, it is a requirement that waste from international flights be incinerated so as not to introduce contaminants between countries. As technologies have improved, most modern incineration plants incorporate heat recovery as well as power generation facilities to recover the heat energy in the waste.

Both landfills and incinerators are effective for managing airport waste, but must be cited with certain considerations in mind. Consider the vehicles and routes needed to transport wastes to these facilities from the gates and terminals, and plan them carefully so they do not disrupt aircraft operations. In many cases the incinerator stacks have to comply with technical requirements (e.g. minimum heights) which might infringe with obstacle limitations and aviation safety. Incinerators give off emissions, and also can give off heat plumes which can affect aircraft flight performance. Facilities would need to be cited with consideration of flight paths into or out of the airport.

The decision whether or not to construct new facilities on site could include financial considerations as well. Airports that have developed waste disposal facilities often charge tenants for waste disposal, or factor it into the lease agreements.

9. CIRCULAR ECONOMY

Disposal of waste has historically been seen as the end stage of a process. However, the concept of circular economy now characterizes it as simply one more transformation in a product lifecycle, and one that can be anticipated and planned for.

What is a circular economy?

A **circular economy** is an alternative to a traditional linear **economy** (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. (www.wrap.org.uk/about-us/about/wrap-and-circular-economy)

Circular economy is beyond waste management

Waste management is an important component in a circular economy. However, the circular economy is a broader concept than waste management and provides holistic approach on elevating waste management into new economic business model:

- The circular economy entails a **new economic mode**l with new circular business models

(e.g. product-service systems) where the value of products (assets) and services is maintained as high as possible;

- The circular economy involves **all stages** of a product or asset lifecycle (product design, production, use **and** waste management).

In such, circular economy products are designed for reuse, disassembly, refurbishment, remanufacturing and/or recycling (Ellen McArthur Foundation, 2017). This results in minimized use of primary (virgin) materials and minimized waste production.

Airports have more opportunities for value creation

Airports are a gathering place for businesses, shops and people and encompass the characteristics of a small city. Airports and the surrounding airport city constitute a broad range of services, products and activities. A circular approach in their waste management and an all-encompassing waste management for the airport will provide room for innovation. This will result in potential cost savings and more value creation opportunities.

Application of circular economy in airports

First step: Analysis of material flows

To grasp circular economy opportunities, the first step is to map the material flows that go in (e.g. fuel, food, products, building materials, water, land) and out (e.g. waste, used products, used building elements, products, waste water, waste land). Of these flows performance data, must be gathered, e.g. on the percentage of recycled or bio-based content and/or percentage of carbon emission reduction.

Second step: Identification of areas for improvements

Second, to find areas with most potential for circular business models, performance data of the use of products must be gathered, such as average lifetimes of products, utilization rates, multifunctionality (number of alternative functions per asset) and resource efficiency (kg/€ or kg/functional unit and/or g CO2/kWh).

To gain further insight in the environmental performance, the environmental impacts of resource flows can be measured using the Lifecycle Assessment (LCA) methodology. The international norm EN15805 is the current prevailing norm to perform LCA studies.

This way the circular performance of the airport and its stakeholders can be measured. When the flows are measured, goals for improvement can be set.

Third step: Implementation of circular business models

To grasp circular economy business opportunities, beneficial for both the financial and environmental performance of airports, new designs of products must be implemented (procured), often together with new business models and new suppliers and value chains. The following six circular business models can be used to facilitate this:

1. **Circular supplies:** fully recyclable materials that are used, for example in drinking cartons and coffee cups, are made from recycled material and can consequently be recycled again. This way input is from secondary resources and output is again an input for another product, replacing the single-lifetime input and thus reducing primary material use.
2. **Dematerialization:** reduce material use with new technologies, such as digital airline tickets that replace paper tickets.
3. **Resource recovery:** food waste and other organic waste can be digested to biogas and the residue of the digestion can be used as fertilizer.
4. **Product as a service:** "Buy light, not lamps". Products don't have to be bought but instead you can pay for the service they provide (for instance light). By paying for a product as a service this will enhance the quality of a product and its lifetime as these benefits the producers of the goods that provide in the service, ultimately will increase the resource efficiency.
5. **Sharing platforms:** Increased utilization rate of a products by sharing. When car owners leave their car at the airport and catch a flight, they can rent it to another person who is arriving at the airport. Instead of paying for parking the car owner now gets paid from the traveller who rents the car.
6. **Product life extension:** Extend working lifecycle of products and components. Buildings and products are modular, demountable and flexible. This improves the ability to adapt, reuse and recycle.

For these various business models hundreds of cases are available which can improve the ecological footprint of the travellers and the stakeholders of the airport and airport city. Within a circular economy approach waste management can play an essential role to avoid, reuse, reduce and recycle the waste on airports. In turn reducing primary material use and costs.

10. REFERENCES

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Cabin Waste Recycling

Aircraft Cabin Waste Recycling Guide. Sustainable Aviation.

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ICAO

ENVIRONMENT

The Eco Design of Airport Buildings

ECO AIRPORT TOOLKIT

The Eco-Design of Airport Buildings

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]:

[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)

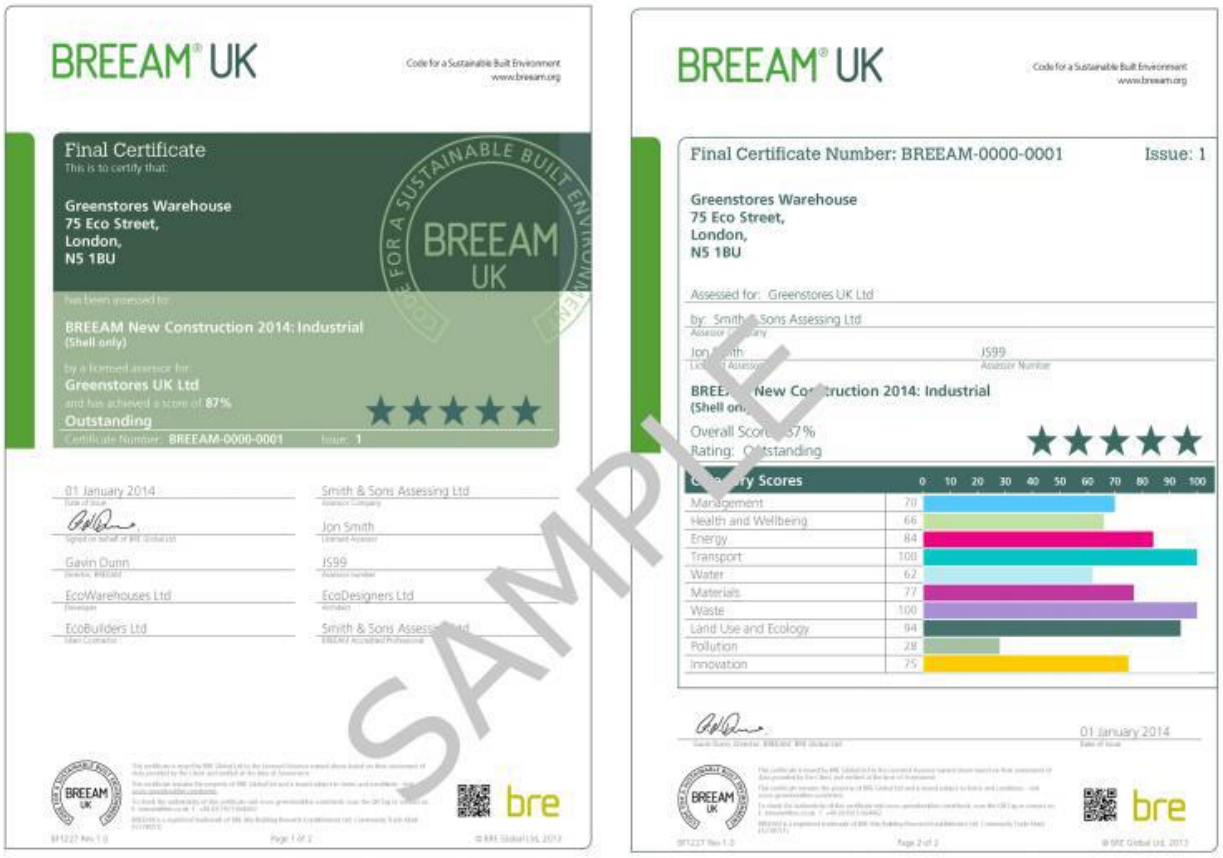

Figure 3. Example of BREEAM certificate post construction

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
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[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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ICAO

ENVIRONMENT

The Eco Design of Airport Buildings

ECO AIRPORT TOOLKIT

Case Studies

The Eco-Design of Airport Buildings (Case Studies)

COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION (CAEP)
AIRPORTS AND OPERATIONS WORKING GROUP (WG2)

ECO AIRPORT TOOLKIT

Zurich Airport (ZRH)

Eco-design of Airport Buildings
A request for case studies

Description of Request

1.1 ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of case studies on the eco-design of their buildings, including aspects of planning, design, construction, operations, and maintenance. The case studies will be included as annexes to the ICAO e-publication "Eco-design of Airport Buildings"

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Emanuel Fleuti
Organization/Company	Zurich Airport
Job Title	Head of Environmental Protection
Email Address	emanuel.fleuti@zurich-airport.com
Telephone	+41-43-816 21 81
Airport *(Name and 3 Letter Code)*	Zurich Airport, ZRH

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: The construction of pier E as part of the fifth expansion

Timeframe (e.g., start and end month/year if applicable): Construction (2000~2002); Operation (2003~)

Description:

Pier E of Zurich Airport was constructed as part of the fifth expansion of the airport. From the beginning, the pier was designed with special consideration to maximize energy efficiency and conserve natural resources. Such features enabled Zurich Airport to expand without increase in total energy consumption. During the construction phase from 2000 to 2002, measures were taken to minimize the adverse environmental effects, such as mandated use of particle filters and on-site concrete manufacturing. The location of the pier situated between runways allowed shorter taxiways for aircraft, thereby enabling emissions reduction, fuel savings, as well as more efficient ground traffic.

Thanks to the development of Pier E and other innovative initiatives, Zurich airport has reduced its own CO2 emissions from scopes 1 and 2 (emission sources owned and operated by Zurich airport and external electricity purchased) by more than 15,000 tonnes (31% reduction) since 1991, despite a 40%increase in infrastructure and a 65% increase in traffic units. The total energy consumption has been stabilized at the 1994 level. This has only been possible through efforts to maximize energy efficiency and conserve natural resources as did in the construction of pier E.

Aircraft Ground Energy Systems (AGES)
Specifically, Pier E aircraft stands are equipped with Aircraft Ground Energy Systems (AGES) that supply aircraft with electricity (400Hz) and Pre-Conditioned Air (PCA). This stationary system allows substantial reduction in fuel consumption and local air quality improvement.

Rainwater Collection
On the roof of pier E, rainwater is collected to be stored in two tanks in the underground. This water is later piped to the 160 toilets and 70 urinals in the building, resulting in about 12,000 m3 of drinking water per year (about one third of total water consumption of pier E) This rainwater collection facility also allows the retention of the precipitation water, limiting the chance of rainwater run offs.

Photovoltaic plant
The roof of Pier E serves a triple functionality: as a solar power plant; shading of the façade; and a design function. With about 5,000 solar modules in an area of 5,800 m2, a mean production of 290,000 kWh is achieved per annum by the roof. The success of this roof was widely recognized, evidenced by the Swiss solar prize award for its solar initiatives.

Glass façade as climate buffer
Pier E benefits from the double glass façades design that functions as climate buffers. The air inside two glass walls and inner-building air is hardly mixed, effectively working as an insulator and maintaining adequate temperature from extreme temperatures. The transparency of glass also allows the airport use natural daylight to a great extent.

Energy piles
Due to the instable soil, the pier was constructed on 441 piles. About 70% of these piles were equipped as energy piles, allowing a seasonal storage of energy. During the summer, excess heat is collected and stored through a system of heat exchange and ventilation, which can later be retrieved in winter. As a result, about two thirds of the cooling and heating demand is covered by this system. The success of this energy conservation was recognized through the Swiss Geothermal Award 2010 by the Swiss Geothermal Society.

Step 3: Have you considered getting a eco-design certification/rating system? Which one?
At the time of design and planning in 1995, eco-design certification or rating systems were not yet very well-known in Switzerland. At the same time, an airport pier didn't match any of the known systems at the time. To this end, Zurich airport decided not to pursue getting a certification.

Step 4: Are you certified by any sustainability rating system? Please identify.
No. However, the project has been awarded with a "Prix solaire" for its photovoltaic plant and with the "Swiss Geothermal-Prize 2010" for the outstanding achievement in using renewable energy.

Step 5: Please identify which area(s) the eco-design project has focused on
(X) Energy efficiency
(X) Emissions
(X) Waste
(X) Water
( ) None
( ) Other _____

Step 6: Please identify and prioritize the driver(s) for the eco-design building project. Number 1-6, where 1 is a high priority and 6 is a low priority.
(2) Economic
(2) Environmental
(1) Political
(2) Social
( ) None
( ) Other _____

Step 7: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentive for the development of such programs? Any specific type of financing that was required? Can you describe it?
In the context of promoting public acceptance for the expansion project, the real estate company (at the time separate from the airport operator), asked for an environmentally outstanding new pier building in a planning and design competition. Accordingly, the evaluation criteria put a high emphasis on the environmental performance of the project. There were no special incentives or financing elements to it.

Step 8: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.
No.

Step 9: Which department is in charge and/or involved in the eco-design of airport buildings in your organization?
Real Estate Division

Step 10: Please insert Text and Images of your project/case study below here:

Lessons Learned:
It has proven essential to specify sustainability criteria in the beginning of the design competition as a leading element. As such, the project proposals were more efficient than if the criteria were to be added at a later stage.

COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION (CAEP)
AIRPORTS AND OPERATIONS WORKING GROUP (WG2)

ECO AIRPORT TOOLKIT

Amsterdam Airport Schiphol (AMS)

Eco-design of Airport Buildings
A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.
This request is for airport operators to use the below template to provide examples of case studies on the eco-design of their buildings, including aspects of planning, design, construction, operations, and maintenance. The case studies will be included as annexes to the ICAO e-publication "Eco-design of Airport Buildings"

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Denise Pronk
Organization/Company	Amsterdam Airport Schiphol
Job Title	Programme Manager Corporate Responsibility
Email Address	pronk_d@schiphol.nl
Telephone	0031653827742
Airport *(Name and 3 Letter Code)*	Amsterdam Schiphol (AMS)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:
1) New Pier (Pier A) – LEED V4 Gold certification;
2) Schiphol Morgue – BREEAM Excellent

Timeframe (e.g., start and end month/year if applicable): Pier A project to be delivered by late 2019; Morgue project ended in late 2017

Description:
In an effort to strengthen our competitive position and ensure that we can continue to offer our passengers and airlines a top-quality product, Amsterdam Airport Schiphol is making substantial infrastructural investments. To support and ensure Schiphol's continued growth, the airport's facilities will undergo extensive expansion and renewal in the years ahead. This will enable us to offer the required extra capacity, improve quality and further optimise processes in the long term.

Purpose

Step 3: Have you considered getting a eco-design certification/rating system? Which one?
Yes, LEED, BREEAM, and Dutch Energy Performance Certificates

Step 4: Are you certified by any sustainability rating system? Please identify.
Pier A – LEED V4 Gold certification; Energy Performance Certificate – to be determined.
Morgue – BREEAM Excellent; Energy Performance Certificate – Label A.

Step 5: Please identify which area(s) the eco-design project has focused on
(X) Energy efficiency
(X) Emissions
(X) Waste
(X) Water
( ) None
(X) Other Well-being and Materials _____

Step 6: Please identify and prioritize the driver(s) for the eco-design building project. Number 1-6, where 1 is a high priority and 6 is a low priority.
(1) Economic
(2) Environmental
( ) Political
( ) Social
( ) None
( ) Other _____

Step 7: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentive for the development of such programs? Any specific type of financing that was required? Can you describe it?

Sustainability is at the heart of Schiphol's strategy, therefore it is difficult to prioritize between the listed drivers. Yet, one requirement for any project by Schiphol is that there exists a sound business case. If it is not the case, non-financial benefits (environment and social impact) should be substantiated enough that the Management Board can weigh all priorities (i.e. besides economic and environment, safety and quality are important consideration as well)

One special consideration to be given to the Morgue Project was the short-planned life span of the building in the current location. The Morgue is expected to be functioning in the current location only for 15 years, with subsequent plan for relocation. Hence, the building had to be constructed with a clear consideration for disassembly.

Step 8: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

Amsterdam Airport Schiphol always engages with internal and external stakeholders and works in coordination with a number of stakeholders. In addition to the relevant trends and developments, Schiphol takes into account the values, interests and views of numerous stakeholders in the decision-making process.

Step 9: Which department is in charge and/or involved in the eco-design of airport buildings in your organization?
The Corporate Development department which is in charge of strategy is also in charge of sustainability. This team sets forth the requirements for new buildings, whereas the business areas are responsible for the execution and implementation of projects.

Step 10: Please insert Text and Images of your project/case study below here:

1) New Pier (Pier A) – LEED V4 Gold certification;

Our new pier is over 55,000m2 in size, equivalent to 11 football fields. The era of sitting in one of those black chairs and simply waiting until boarding time is almost over. The new pier will have comfortable lounge chairs for relaxation, high-top tables for working and last-minute shopping outlets. The pier's open layout means travellers can see the boarding process begin – even when they aren't waiting at the gate. There are trees, flowers and plants all over the new pier. The new pier is green in more ways than one. We have carefully considered various ways of reusing energy and using reusable or sustainable materials in the design of the new pier. The ceiling is made of reusable plastic, marble rubblework tiles and 5,000 m2 of solar panels. We flush the toilets using rainwater, and much of the floor is made of bamboo. Schiphol

Schiphol built this new facility according to the cradle-to-cradle principle. When a structure's lifespan has ended, the materials can be easily reused in a new project. It is the first 100% cradle-to-cradle building at and belonging to Schiphol.

2) Schiphol Morgue – BREEAM Excellent

Amsterdam Airport Schiphol opened a new morgue late last year which achieved a BREEAM rating of Excellent. This construction standard was achieved through insulating and energy-generating applications, such as the climate resilient circular water system that drains away waste water more slowly and filters it – rain water is captured to flush toilets. Electricity is supplied by solar panels and the building is lit by LED lighting. The building uses a heat pump so no natural gas is needed. Furthermore, there is an ecological plan for the morgue. It has a 'Green' roof and designated area for bees. Bees are an essential part of our ecosystem, and we want to support them because bee populations are dwindling. ENS technology captures particulate matter, thereby ensuring a healthier general environment and working environment. The architect designed the building according to the Fibonacci Sequence. By doing so, he used the principles of nature what makes that whether one is alone in the mortuary or with a big group; that way, the building always feels respectful and comfortable. This was the main objective when the building was designed.

Decision-Making Process:

Estimated Cost and Financial mechanisms available:

n/a

Images:

Lessons Learned:

Schiphol's suggestion for other airports to consider in eco-design project can be explained in one key word, the 'integration'; incorporating sustainability requirements from the very beginning of any project.

From the initial stage in exploring the right contractors to design the buildings, it is crucial to ensure project personnel are knowledgeable and experienced with the sustainability requirements. This step is essential as ambitious goals would not be achieved without sustainable design. Once the project is rolled out for implementation, sustainability officer should continuously corroborate with the architect and construction project manager that sustainability requirements are appropriately translated into the design and construction along with other safety and financial constraints set by the airport. Furthermore, contract managers should practice continuous oversight to ensure that the highest standards set forth for health, safety, environment, and quality compliances are maintained throughout the process, and every practice is carried out in accordance with the agreed terms.

COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION
(CAEP) AIRPORTS AND OPERATIONS WORKING GROUP (WG2)

ECO AIRPORT TOOLKIT

Carrasco International Airport (MVD). Uruguay

Eco-design of Airport Buildings

A request for case studies

Description of Request

1.2 ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "epublications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of case studies on the eco-design of their buildings, including aspects of planning, design, construction, operations, and maintenance. The case studies will be included as annexes to the ICAO e-publication "Eco-design of Airport Buildings"

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Jorge Navarro Pastorino
Organization/Company	Corporación América Uruguay
Job Title	Maintenance and Infrastructure Manager
Email Address	Jorge.navarro@aeropuertodecarrasco.com.uy
Telephone	+59826040329 ext. 1615
Airport *(Name and 3 Letter Code)*	Aeropuerto de Carrasco - MVD

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:

Aeropuerto de Carrasco Energéticamente Eficiente

Timeframe (e.g., start and end month/year if applicable): 2015 to 2018

Description:

Aeropuerto de Carrasco's commitment to an environmentally friendly, sustainable operation.

A strong commitment for sustainability is at the heart of Corporación América, which has consistently been striving to mitigate the environmental impact of its operations, aiming to transform Aeropuerto de Carrasco into a "green airport".

In this regard, the company implemented a Residue Management Plan, along with an Energy Management System, aimed at the removal of fossil fuel usage, to be achieved by reducing heating consumption by 40%, and cooling consumption by 20%; increasing performance by 400% and avoiding the annual consumption of 122,400 m3 of natural gas.

The success of these measures, which in the year 2016 earned the Ministry of Industry, Energy and Mining's recognition through the National Energy Efficiency Prize, involved modifying the airport's Air Conditioning System. The company replaced the natural gas heating units with more efficient, electricity powered units.

The terminal area's air conditioning units include an air routing system which allow them to either process return or exterior air (free cooling). Along with the glass surface of the structure, which improves thermal insulation and reduces energy expense, free cooling has been optimized, further increasing the building's efficiency.

Adding to these measures, a new Photovoltaic Solar Power Plant was set up on a one hectare field in the airport's premises, and is made up of 1540 photovoltaic panels placed along seven rows, from north to south. Using next generation solar tracking technology, it is able to produce 25% more energy than traditional mobile panels.

This solar plant is meant to allow for 10% of the terminal's yearly power consumption to be covered by renewable energy, which constitutes a reduction of 352 tons of CO2 released into the atmosphere per year.

This year (2018) we are in the process of replacing conventional luminaires with new lamps with LED technology

Purpose

Step 3: Have you considered getting a eco-design certification/rating system? Which one?

The successful application of its Sustainability Plan, carried out through all of these measures, enabled Aeropuerto de Carrasco to complete its level 1 Airport Carbon Accreditation (ACA), awarded by the Airports Council International (ACI), in virtue of the low carbon emissions. This award allows Uruguay to be included in a list of eight Latin American countries with low environmental impact airport operations. Additionally, the airport terminal is a permanent member of the ACI's Latin America Environmental Committee, and is ISO 14064-1 certified, which is an international standard for the quantification and reporting of greenhouse gas emissions.

Corporación América is committed to continuous growth and investment into innovation for the lowering of its carbon footprint, while remaining faithful to the best quality and safety standards.

Step 4: Are you certified by any sustainability rating system? Please identify.

Step 5: Please identify which area(s) the eco-design project has focused on

(x) Energy efficiency

(x) Emissions

( ) Waste

( ) Water

( ) None

( ) Other _____

Step 6: Please identify and prioritize the driver(s) for the eco-design building project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(2) Environmental

(1) Political

(4) Social

( ) None

( ) Other _____

Step 7: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentive for the development of such programs? Any specific type of financing that was required? Can you describe it?

Previously, there was no legal framework for the generation of power for self-consumption. The Airport worked alongside the Ministry of Industry, Energy and Mining, in order to enable the project, after which the Ministry issued the Decree 043/15, which enabled all Large Consumers to generate power using renewable sources, for selfconsumption, without the possibility of routing surplus power into the main grid.

The project was financed by the company itself.

In Uruguay, there is an Investment Law, which promotes investments which have a positive impact in the environment or employment. We were granted a corporate tax (IRAE) exemption of 30%.

Step 8: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

We worked with the Uruguayan Ministry of Industry, Energy and Mining, the National Directorate of Civil Aviation and Aeronautic Infrastructure (DINACIA), and with the state owned national electric power company.

Step 9: Which department is in charge and/or involved in the eco-design of airport buildings in your organization?

The department of Maintenance and Infrastructure.

Step 10: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

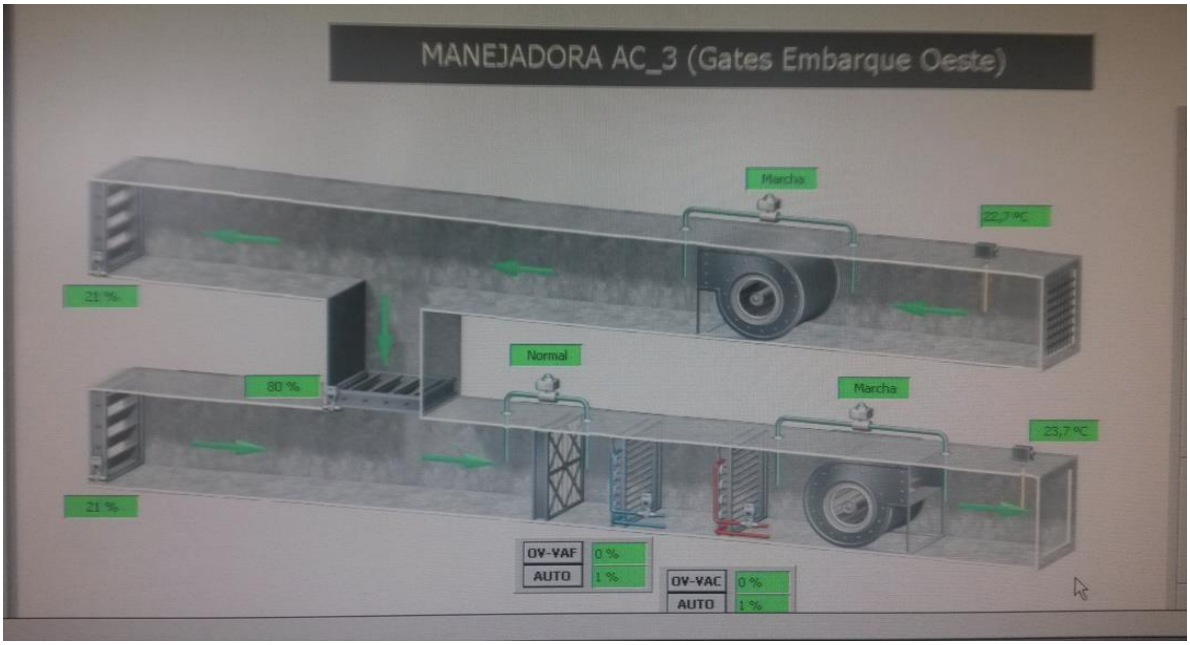
Estimated Cost and Financial mechanisms available:

Proyecto	Cost (USD)	Saving (USD/year)	Reduction of emissions of CO2 (tCO2 / year)
Heat pumps	600000	150000	346
Free Cooling	75000	52000	85
Solar photovoltaic generation	900000	110000	352
Lamps LED	700000	50000	146
Total	**2.275.000**	**362.000**	**929**

Images:

Heat Pumps

Free Cooling



Solar Photovoltaic Plant

LED ERCO brand lamps - Germany

Lessons Learned:

Having successfully completed this ambitious company has made us at the company and the workforce proud. We are now a regional example of good environmental practices.

This kind of projects are generally regarded as important, with a very long term return of investment, however after carrying out various financial analyses, we have concluded that in addition to being environmentally positive projects, they are economically viable as well.

COMMITTEE ON AVIATION ENVIRONMENTAL PROTECTION
(CAEP) AIRPORTS AND OPERATIONS WORKING GROUP (WG2)

ECO AIRPORT TOOLKIT

Midfield Terminal Building, Abu Dhabi, United Arab Emirates

Eco-design of Airport Buildings

A request for case studies

Description of Request

1.3 ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "epublications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

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Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	**Christine Eid**
Organization/Company	**Abu Dhabi Airports (ADAC)**
Job Title	**Senior Sustainability Manager**
Email Address	**ceid@adac.ae**
Telephone	**+97125056223**
Airport *(Name and 3 Letter Code)*	**Midfield Terminal Building (not yet in operation)**

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:

Midfield Terminal Building (MTB) – Climate Responsive Design

Timeframe (e.g., start and end month/year if applicable):

Design Stage

Description:

A Climate responsive design takes into account the specific local climatic parameters which have direct influence mainly on indoor thermal comfort and energy consumption in a building.

This is achieved through a combination of Passive and Active design measures

Purpose:

- to provide and moderate the adequate indoor environment;
- to allow for a greater degree of control over the internal climate and to further enhance human comfort;
- and subsequently, reduce energy consumption.

Step 3: Have you considered getting a eco-design certification/rating system? Which one?

Yes, the MTB design has achieved the 3 Pearl rating for Estidama; as such, the MTB is the largest single building to be ever rated globally, and is the highest rated airport terminal in the region. The MTB is now pursuing the Estidama construction rating.

Step 4: Are you certified by any sustainability rating system? Please identify.

Yes; the MTB is currently certified 3 Pearl under the Estidama Pearl Rating System.

Estidama is a building design methodology for constructing and operating buildings and communities more sustainably. The program is a key aspect of the "Abu Dhabi Vision 2030" drive to build the Abu Dhabi Emirate according to innovative green standards. "Estidama" is the Arabic word for sustainability. The program is not itself a green building rating system like LEED or BREEAM, but rather a collection of ideals that are imposed in an elective building code type of format.

Within Estidama, however is a green building rating system called the Pearl Rating System that is utilized to evaluate sustainable building development practices in Abu Dhabi.

Step 5: Please identify which area(s) the eco-design project has focused on

(X) Energy efficiency

( ) Emissions

( ) Waste

( ) Water

( ) None

( ) Other _____

Step 6: Please identify and prioritize the driver(s) for the eco-design building project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(**3**) Economic

(1) Environmental

( ) Political

(2) Social

( ) None

( ) Other _____

Step 7: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentive for the development of such programs? Any specific type of financing that was required? Can you describe it?

The Estidama program is mandatory in Abu Dhabi, United Arab Emirates - all buildings must achieve a minimum 1 Pearl Rating, and all government-funded buildings must achieve a minimum 2 Pearl Rating (5 Pearl rating being the maximum).

During the design stage of the MTB, ADAC have identified greater opportunities for design optimisation which would result in greater O&M savings; and so ADAC decided to go for a higher rating than the minimum mandatory 2 Pearl. The MTB is currently certified 3 Pearl under the Estidama Pearl Rating System, and is pursuing the same level for the construction rating.

There are no other incentives for the implementing Estidama into the airport projects.

Step 8: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

Extensive engagement with internal and external stakeholders was undertaken throughout the design stage and decision making process.

Internal stakeholders:

- Project Board – for decision making and approval;
- Operations & FM – for O&M requirements or constraints;
- Projects Program Controls – for cost analysis and program controls;
- Procurement & Contracts – for market readiness assessment and contract inclusion. External stakeholders:
- Airlines;
- Concessionaires;
- Department of Urban Planning and Municipalities;
- Utilities providers (energy, water and sewerage);
- Department of Transport;
- The Environment Agency.

Step 9: Which department is in charge and/or involved in the eco-design of airport buildings in your organization?

ADAC CP&C (Capital Projects & Construction) division is responsible for the development and delivery of the capital expenditure programme for ADAC airports, and so also in charge of the design and construction process – including eco-design and eco-construction – of all the airport projects.

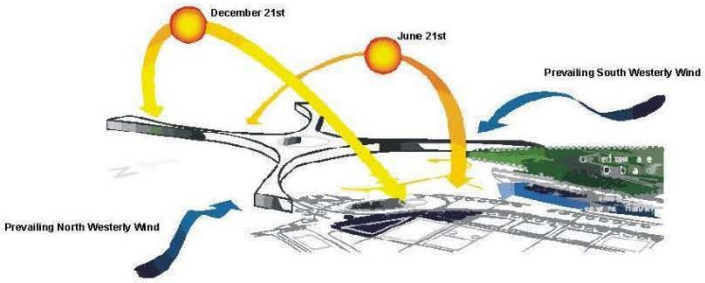
Step 10: Please insert Text and Images of your project/case study below here:

MIDFIELD TERMINAL BUILDING

PASSIVE & ACTIVE DESIGN

A Climate responsive design takes into account the specific local climatic parameters which have direct influence mainly on indoor thermal comfort and energy consumption in a building.

This is achieved through a combination of Passive and Active design measures;



- **Passive Design** considers its specific site planning and takes advantage of the local climate enabling the structure to naturally assist the building in its ability to provide and moderate the adequate indoor environment.
- **Active Design** supports and complements the passive features to allow for a greater degree of control over the internal climate and to further enhance human comfort.

PASSIVE DESIGN

CLIMATE RESPONSIVE

The central processor roof of the MTB spans above main passenger spaces of the terminal building articulated as a tent-like undulating surface suspended over 52m high, 180m large span arches.

It represents a wave like profile to the front of the building cantilevering out at an average of 15m beyond the processor façade, self-shading the entire front porch of the terminal.

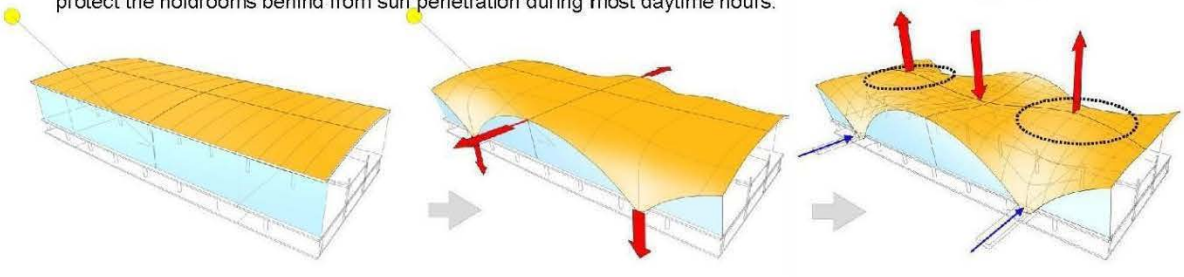
The roof is perforated by skylights along the spine of the building offering a daylight path inviting passengers and guiding them through to the center of building.

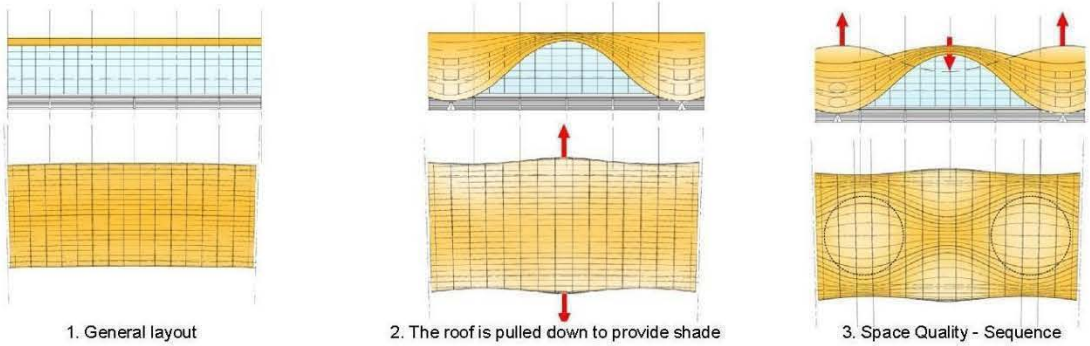
PASSIVE DESIGN

MASSING & ORIENTATION

The arch shaped roof geometry of the piers with the roof surface being pulled down at each segment protects the building from the sun and at the same time creates a continuous undulating form echoing the desert dunes of the Emirates.

The glazed parts of the undulating pier façades are canted 14.75° towards the outside, to protect the holdrooms behind from sun penetration during most daytime hours.





1. General layout

2. The roof is pulled down to provide shade

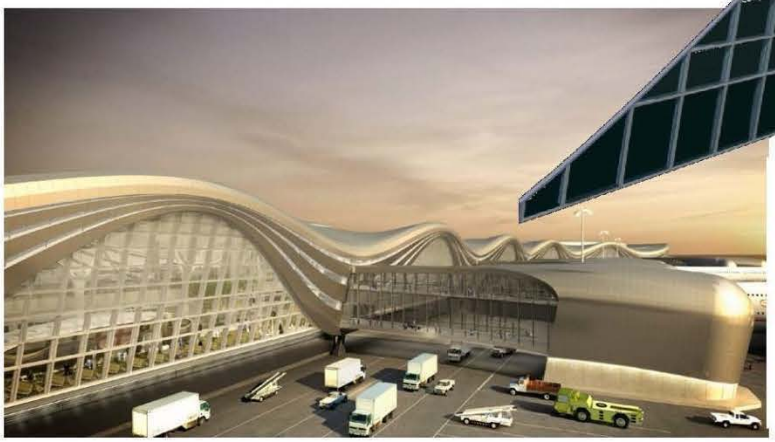
3. Space Quality - Sequence

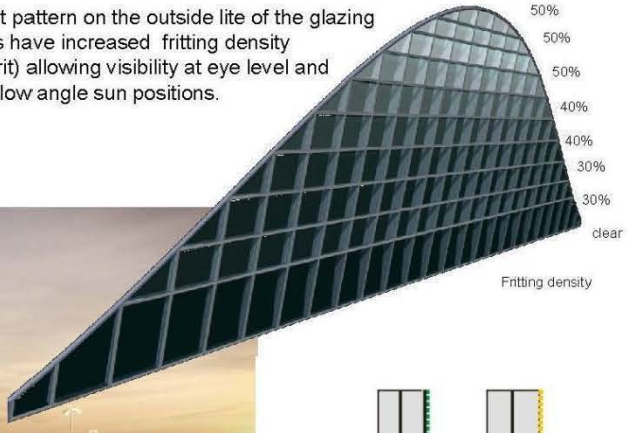
PASSIVE DESIGN

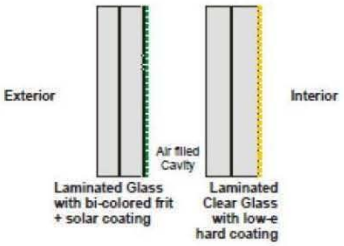
HIGH PERFORMANCE SELF-SHADING FACADES

The insulated double glazing facade is equipped with high performance selective coatings to efficiently filter daylight from unwanted non visual solar radiation wavelengths to reduce solar gains allowing 34% of the sunlight through the clear glass to pass but let only 21% of the solar heat gain enter the building.

In addition to that, the façade glazing have a ceramic frit pattern on the outside lite of the glazing assembly that blocks the suns radiation. These patterns have increased fritting density from bottom (no frit = clear glass) to top (50% opaque frit) allowing visibility at eye level and effectively reducing the solar radiation entering even at low angle sun positions.







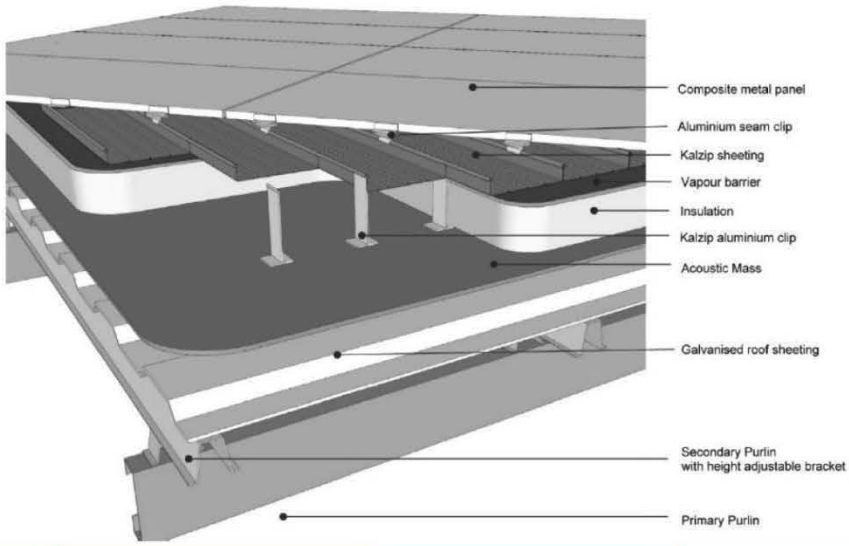
PASSIVE DESIGN

DOUBLE SKIN ROOF

The building envelope is equipped with a ventilated secondary skin to reduce heat transmission through opaque surfaces. The cavity between the internal and external roof skin layers is ventilated to the outside to reduce heat accumulation within the envelope.

The whole envelope and all openings are highly sealed against unwanted air infiltration from the outside as the extremely high humidity levels of the ambient air could lead to condensation issues at internal surfaces and increase dehumidification loads of the building.

The improved infiltration rate contributes to the reduction in the overall energy demand by 5.8%.

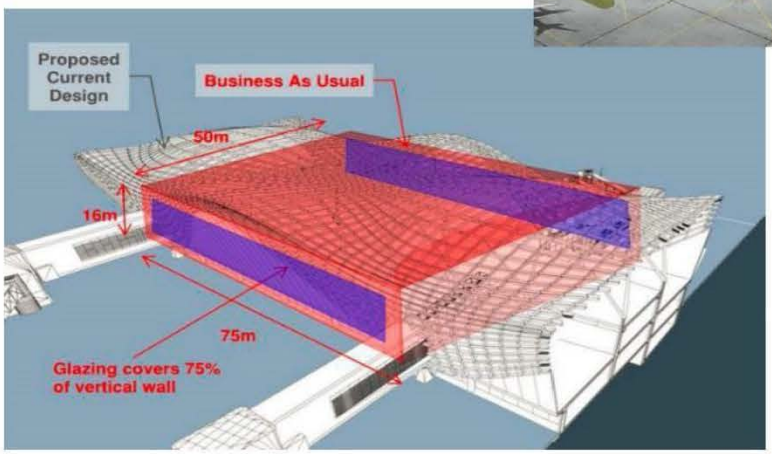


PASSIVE DESIGN

PASSIVE DESIGN – CASE STUDY

A life cycle cost benefit study was undertaken in order to assess the MTB building envelope and form design taking into consideration initial investment costs towards passive strategies and its eventual financial benefits.

This study was primarily undertaken to inform effective long-term decisions about both the building design and construction, as well as the building operation in order to maximize efficiency over the whole life cycle of the development.



The study resulted in the demonstration the current MTB enveloped design, for the area size of 75m x 50m, encompassing the proposed passive design strategies will result in the following:

- Total energy saving: 445,000 kWh/annum
- Total utility cost saved: 48,505 AED/Annum

ACTIVE DESIGN

MECHANICAL SYSTEM OPTIMIZATION

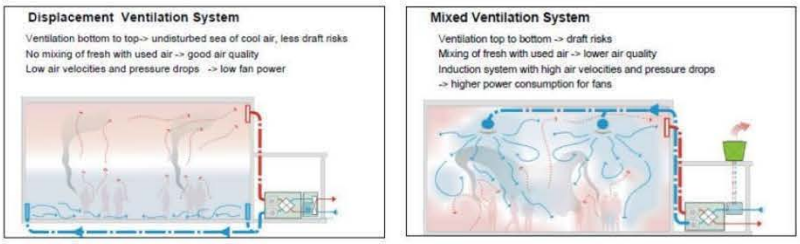
Occupancy controlled Ventilation

Passenger flows and occupancy profiles show a great variety of occupation density within the building. Peak times are around midnight and in the morning hours, while during other times of the day occupancy drops down as far as 20 – 40% of the peak occupancy. Therefore outdoor air supply will be controlled depending on actual occupancy of a space implementing CO_2 sensors in the return air system to control air flow based on demand.

Additionally, Temperature sensors installed throughout the terminal are linked to the AODB (Airline Operation Data Base) where temperature is controlled during occupied periods and permitted to drift up during unoccupied periods.

These measures significantly reduce the outdoor air loads and ventilation temperatures required for sensible cooling and dehumidification.

Displacement Ventilation System



By displacement ventilation system, the air is supplied near the floor to a distance of 10-15m and exhausted near the ceiling. This requires lower air volume movement rates, leading to lower fresh air intake rates and less electricity required to drive the fan for both air exhaust and supply.

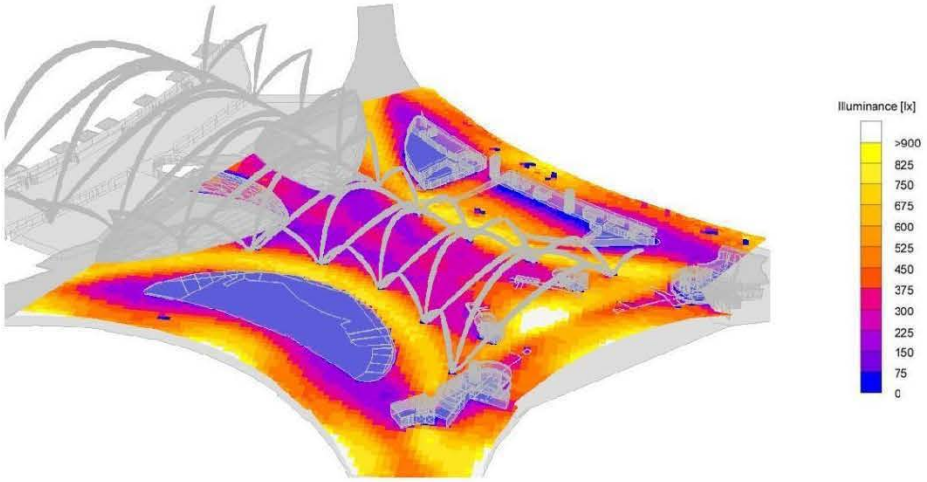
The air flowing in one direction (bottom to top) reduces drafts risk and prevents the mixing of fresh air with the used air. This results in a significant increase in thermal comfort for the passengers.

ACTIVE DESIGN

INTELLIGENT LIGHTING CONTROL SYSTEM

According to daylight simulations, more than 75% of publicly-occupied spaces will have a minimum of 250 lux daylight illuminance under clear skies at equinox and summer solstice. A daylight simulation for overcast conditions was also performed indicating adequate daylight in all public areas except Baggage Claim, which has very limited exterior exposure and requires artificial lighting under all circumstances.

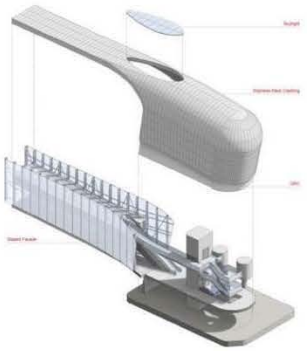
Photocell controllers are installed to provide daylight sensitive switching to designated lighting channels and scenes only when needed and dimming artificial lighting to the minimum when not needed – during off-peak hours. As a result, Lighting Loads were reduced by 24.1%.



ACTIVE DESIGN

ENERGY EFFICIENT FIXTURES & EQUIPMENT

PCAs are installed in the basement of the bridges resulting in a 20% reduction in energy consumption over traditional exposed location.



Efficient baggage handling System conveyor section is independently controlled and features a unique start/stop function which intelligently powers-off sections immediately when not in use. This advanced technology not only reduces total energy consumption by 60%, compared to a conventional conveyor system, but also reduces maintenance costs.

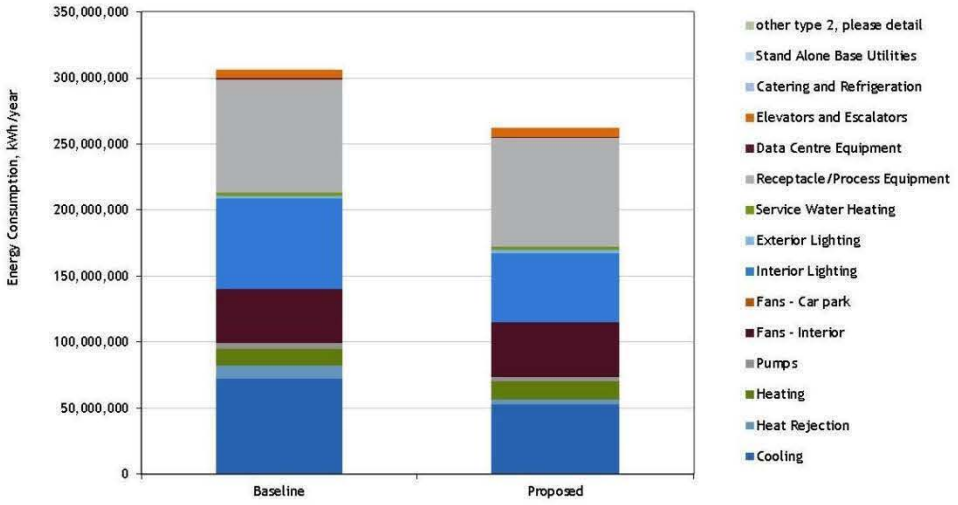
Selection of energy efficient equipment and appliances
All appliances (FIDS, ad screens, computers, etc…), office equipment and transportation devices such as elevators (159 no.), escalators (122 no.) and moving walkways (58) are certified energy efficient.

ENERGY MODELING

REDUCED DEMAND & SYSTEMS OPTIMIZATION

Extensive energy modeling demonstrated **14.5% overall energy use reduction**

- Lighting Loads were reduced by **24.1%** through careful design of lighting levels and day-lighting controls.
- Cooling Loads were reduced by **27.1%** through the design of displacement ventilation, energy wheels, series chillers in the central utility plant and demand based ventilation using CO2 and temperature sensors.
- Pump Loads were reduced in the proposed building design by **22.1%** as a result of the reduced cooling loads.
- the Baggage Handling System operational load was reduced by **60%** compared to a traditional system.



Decision-Making Process:

Each feature of the eco-design was evaluated from a capital cost and construction time impact perspective; it was also evaluated from an Operational perspective in terms of challenges or constraints. A market readiness assessment was also undertaken for products and material availability. The design team have also compared the proposed design to a baseline (as per code) case, highlighting the energy reduction benefits of the eco-design.

Then a report including all the above findings was raised to the project board for decision-making and final approval.

Estimated Cost and Financial mechanisms available:

We've shared in the slides above a brief summary of a cost benefit analysis undertaken on a small portion of the building considering only the passive design elements. Please refer to slide 7. More information is available if needed.

The combination of passive and active design elements were evaluated from an energy efficiency perspective only through energy modeling where a reduction of 14.5% on the overall annual energy consumption over a baseline was achieved. This would equate to a considerable saving on the utility cost.

Lessons Learned:

1. Start early in the design stage;
2. Set minimum expected levels of efficiency and targets for energy consumption reduction;
3. Include requirements for dynamic energy simulation (energy modeling) to be done at a stage where the design can still be influenced by its results and can be modified accordingly;
4. Prioritise the passive design strategies as those are the most effective solutions to reducing a building cooling demand;
5. Model the passive design strategies separately and determine the cost savings resulting from them as those savings will be continuous and stable throughout the life cycle of the building.

— END —

ICAO

ENVIRONMENT

A Focus on the production of renewable energy at the Airport site

ECO AIRPORT TOOLKIT

Case Studies

Case Studies on Renewable Energy

Table of Contents

Case Study on Renewable Energy

Zurich Airport (ZRH)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Emanuel Fleuti
Organization/Company	Zurich Airport
Job Title	Head of Environment
Email Address	emanuel.fleuti@zurich-airport.com
Telephone	+41-43-816 21 81
Airport *(Name and 3 Letter Code)*	Zurich Airport, ZRH

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Photovoltaic Plant on Passenger Pier

Timeframe (e.g., start and end month/year if applicable): 2 years (2000-2002)

Description: A photovoltaic plant of total 5,800 m2 surface on the roof of passenger pier E provides approx 260 MWh/a

Purpose: Build an environmentally friendly passenger terminal

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(1) Environmental

(4) Political

(2) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Commitment to build an environmentally friendly passenger terminal

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

No.

Step 7: Which department is in charge of the renewable energy development in your organization?

Environment

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

The requirement for an environmentally conscious pier was stipulated in the scope of work for the architectural competition. The architect suggested – among other initiatives – the PV plant. The airport project steeringcommittee awarded the pier design to this architect, honoring all environmental initiatives planned for this pier.

Estimated Cost and Financial mechanisms available:

Initial Investment	CHF 3'000,000
Annual Running Cost	CHF 227,000
Annual Financial Savings	CHF 264,000

Images:

Results (Environmental Benefit/Cost Benefit):

- Energy/fuel benefits
- CO2 / GHG benefits
- Reduction of resource usage
- Community/Public Relations
- Income generation
- Benefit Metrics: 0.86 CHF/kWh
- Annual Energy Savings: 290MWh

Lessons Learned: No hurdles/disadvantages

Case Study on Renewable Energy

Kuala Lumpur International Airport (KUL)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Ir. Mohd Hakimi Uda Ahmad
Organization/Company	Malaysia Airports Holdings Berhad (MAHB)
Job Title	Manager, Energy Management Unit of Engineering MAHB
Email Address	hakimi@malaysiaairports.com.my
Telephone	603-877 77169
Airport *(Name and 3 Letter Code)*	Kuala Lumpur International Airport (KUL)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:

Solar Photovoltaic (PV) Power Generation System at Kuala Lumpur International Airport (KLIA) Timeframe (e.g., start and end month/year if applicable):

January 2012 – November 2013

Description:

This project is a Development, Design, Engineering, Supply, Installation, Testing, Commissioning, Operation, Management and Maintenance of 10MW Peak Photovoltaic Solar System at KLIA Long-Term Carpark and 4MW Peak Photovoltaic Solar System at KLIA Roof Top Satellite Building- Concession between MA (Sepang) Sdn.Bhd and Business Ventures.

Purpose:

To participate with government initiatives on Solar Photovoltaic power generation system with Feed-in-Tariff (FiT) program. The main purpose of this project is to reduce carbon emission and dependency of electricity grid while supporting the MAHB's Energy Policy in-line with 40% carbon reduction by 2020 as pledged by our Honourable Prime Minister in Copenhagen (COP-15) in December 2009. In Paris conference 2015, the new target reduction is 45% carbon emission by 2030.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(□) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

( ) Political

( ) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Environmental and economic factors are the biggest drivers that encourage MAHB to explore the field of clean energy generation. The environmental factor is strengthen up by MAHB's Energy Policy to improve energy consumption efficiency, reduce utility cost, optimize capital expenditure for energy efficiency and strive to become a world-class energy management in airports industry, which in-line with 40% carbon reduction by 2020 as pledged by our Honourable Prime Minister in Copenhagen (COP-15) in December 2009. While for the economic factors, the potential of the Solar photovoltaic generation revenue via Feed-in-Tariff (FiT) programme that obliged distribution licensee to buy energy from FiT holders based on electricity produced at an attractive rate. The power generated from solar PV system was injected into KLIA electricity grid and utilized for their electricity consumption.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

The MAHB's internal stakeholders engaged during this project are Engineering Division, Planning and Development (P&D), Legal, Procurement Division (PCD), Resident Electrical Engineer MA(S), Land Division, Commercial Division and Financial Division. The external stakeholders engaged during this project are Corporate Season Sdn Bhd and Silverstar Pavilion Sdn Bhd, Sustainable Energy Development Authority Malaysia (SEDA Malaysia)

Step 7: Which department is in charge of the renewable energy development in your organization?

Energy Management Unit of Engineering MAHB & Resident of Electrical Engineer MA(S)

Step 8: Please insert Text and Images of your project/case study below here:

Caption 1 – Installation Works

Caption 2 - Roof Top, Satellite Building KLIA

Caption 3 – Long Term Car Park KLIA (10MW)

Decision-Making Process:

The decision-making process has been done via Board Procurement Committee of MAHB

Estimated Cost and Financial mechanisms available:

The Estimated Cost for this project is at USD 44mil in 2013 and financial mechanism applied in this project was via Feed-in-Tariff program that obliges Distribution Licensees (DLs) to buy from Feed-in Approval Holders (FIAHs) the electricity produced from renewable resources (renewable energy) and sets the FiT rate. The DLs will pay for renewable energy supplied to the electricity grid for a specific duration. By guaranteeing access to the grid and setting a favourable price per unit of renewable energy, the FiT mechanism would ensure that renewable energy becomes a viable and for long-term investment for companies and industries.

Results (Environmental Benefit/Cost Benefit):

This solar photovoltaic project are able to generate electricity at an average of 18,638 MWh electricity per year which contribute to reduce 13,811 tCO_2 per year equivalent to 2,868 houses energy consumption for one year and avoid 6,989 ton of coals burned for power generation. The cost benefit for this project is equivalent to USD 0.6

Million of electricity reduction annually compare to year 2012 as baseline.

Lessons Learned:

The great benefits of this project in term of environmental and financial impact that helping our organization to reduce utilities cost and sustaining a high service level of power system. The CO_2 emission reduction will also contribute to reduce the impact of global climate changes. Therefore, MAHB plan to continue the implementation of this initiative to other airports and contribute towards a greener environment.

Case Study on Renewable Energy

Cochin International Airport Limited (COK)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	A Chandrakumaran Nair
Organization/Company	Cochin International Airport Limited (CIAL)
Job Title	Airport Director & ED-Operations
Email Address	acknair@cial.aero/apd@cial.aero
Telephone	0484-2610004
Airport *(Name and 3 Letter Code)*	Cochin International Airport Limited (CIAL)-COK

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: 12 MWp Solar PV Power plant at Cochin International Airport

Timeframe (e.g., start and end month/year if applicable): NA

Description: ------

Purpose: To see whether the solar power generation can be effectively used for offsetting the huge electricity bills of the airport as well as a message to the world that sustainable energy of the future is solar PV

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(*) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Economic

(3) Environmental

( ) Political

(2) Social

( ) None

( ) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

The power supply provided KSEB Ltd had increased the cost of the power supplied to the airport around 50% during the revision of power tariffs. Also CIAL had been promoting green initiatives. Hence the subsidy available during that period from Indian Government had been availed to set up a trial plant of 100 kWp for observation purpose. The above plant had been installed successfully during March 2014 and the performance of this plant gave a confidence to further increase the capacity.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

No

Step 7: Which department is in charge of the renewable energy development in your organization?

CIAL have formed a wholly owned subsidiary company named CIAL Infrastructures Ltd for developing such kind power projects which mainly was focussing on generation of power from renewable resources.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: - The proposal from lower management would be approved by the higher management team after discussing the same in details which in turn would be submitted for the approval of the Board of Directors. After the approval of the Board, the work would be tendered after advertising in the newspapers, websites etc. Thereafter opening the tender on the prescribed date, in the normal case lowest bidder would be awarded with the work.

Estimated Cost and Financial mechanisms available: Estimated cost of the work would be assessed primarily based on the market survey and after getting budgetary quotes from vendors. The average estimated cost for the solar installation when it was tendered had been 5.1 Cr per MWp. After opening of the tenders, the final rates would be verified by the financial approval committee and approval would be provided for the work.

Images:

Results (Environmental Benefit/Cost Benefit): The solar PV power is considered as the greenest form of electricity and is a renewable source. Hence is the most environmental friendly installation. According to the environmental protocol, by using solar PV energy, the production of carbon dioxide would be reduced and due to this the presence of it in the atmosphere would come down. This decreases the global warming process which is harmful to the earth's environment. The present cost of the solar PV power has come down to the equivalent of coal power. Hence, it is almost come at par with the normal grid power cost.

Lessons Learned:

1. CIAL had lot of land kept unutilized for years. This land is converted to the solar field which when in need may be after a span of 15years or so can be replaced to the roof tops. By the time the solar plant might have given its payback. So effective land utilization.
2. By decreasing the dependency on the grid, we can help in reducing the carbon emission process

3. Kerala's climate had been believed to be non-solar friendly. But in fact there is not much reduction in the solar irradiation even during the monsoon. It was assumed that due to the extended monsoon season of Kerala solar production would be uneconomical. This myth was busted although some percentage of the productivity would be affected during the cloudy times.

4. The effective use of solar power can actually reduce the losses in the transmission and help in preserving the hydel energy for non-solar time.

5. All the house hold roof tops can be effectively utilised for the production of solar PV power and can become self-sufficient.

6. Where land is not available or costly, the lakes, dams and canals in the state can be utilized for the solar power generation by laying the solar panels above these.

7. The conversion of car parking area with solar powered roofs have advantage that besides getting shadow to the car, electric power can also be produced from the roof.

8. The solar plant area can also be utilized effectively for cultivation for different agricultural products by effectively using the space.

9. The water used for cleaning of the solar modules to wash dust and dirt can be utilised for watering the agricultural plants below.

The land which was previously required to have financial expenditure has turned to revenue earning.

Case Study on Renewable Energy

Narita International Airport (NRT)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Kazuya Tamaki
Organization/Company	Narita International Airport Corporation
Job Title	Senior Manager
Email Address	k-tamaki@naa.jp
Telephone	
Airport *(Name and 3 Letter Code)*	Narita International Airport (NRT)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Solar Power Generation

Timeframe (e.g., start and end month/year if applicable): In operation

Description: The approximately 2,000kW Solar Plant located on airport land adjacent to Narita International Airport began operations in March 2015.

Purpose: Selling electric power

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1is a high priority and 6 is a low priority.

(1) Economic

(2) Environmental

(4) Political

(3) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Feed-in tariff system guarantees that the power supplier buys the photovoltaically-generated electricity. The buying rate of electricity depends on when you join the program. Those who introduced PV earlier can sell electricity for higher price than the later-comers.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Step 7: Which department is in charge of the renewable energy development in your organization?

Department in charge of facility management.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: N/A

Estimated Cost and Financial mechanisms available: N/A

Images: Visit our website to refer Environment Report.

Global Environment Initiatives - Solar Power Generation (Page 23)

http://www.naa.jp/en/environment/environment.html

Results (Environmental Benefit/Cost Benefit): N/A

Lessons Learned: N/A

Case Study on Renewable Energy

Kansai International Airport (KIX)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Hiroya Shintani
Organization/Company	Kansai Airports
Job Title	Manager
Email Address	hiroya.shintani@kansai-airports.co.jp
Telephone	+81-724552176
Airport *(Name and 3 Letter Code)*	Kansai International Airport (KIX)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: KIX Clean Power Energy (Solar and wind)

Timeframe (e.g., start and end month/year if applicable): Operation since February/2012

Description: There are almost 77,000 Photovoltaic panels on the ground and rooftops in the airport and three small window turbines. The total capacity is approximately 12MW. It is possible to reduce almost CO_2 emission by 4600tons/year.

Purpose: To ensure a stable supply of electricity and contribute to prevent global warming. Including the currently running solar power generation, clean energy accounts for 9.5% of the total electricity in the airports. Solar power generation is based on the Feed-in Tariff System for renewable energy. The power by the small window turbines are supplied to some of the street lights.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(*) Solar PV

( ) Solar Thermal

(*) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(4) Economic

(1) Environmental

(2) Political

(4) Social

(6) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

We lease the space for the solar power generation and receive the rental fee form the generator company.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

We set up the environmental policy and engaged to install the renewable energy power inside the airport.

Step 7: Which department is in charge of the renewable energy development in your organization?
Environment management section

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: N/A

Estimated Cost and Financial mechanisms available: N/A Images:

Results (Environmental Benefit/Cost Benefit): Reduction of 4600t Co2

Lessons Learned: N/A

Case Study on Renewable Energy

La Palma Airport (SPC)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Manuel Cantos Sánchez
Organization/Company	Aena, S.A.
Job Title	Quality and Environmental Department
Email Address	Ctra. La Bajita S/N
Telephone	+34 922 42 61 77
Airport *(Name and 3 Letter Code)*	La Palma SPC

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Wind turbines in the Airport of La Palma

Timeframe (e.g., start and end month/year if applicable): Starting in the year 2003 (second semester) until nowadays

Description: Implementation of 2 wind turbines to supply electricity to La Palma Airport.

Purpose: Use of renewable energies instead of non-renewable ones contributing to the sustainable development of La Palma island, declared by the UNESCO as a World Biosphere Reserve.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

( ) Solar PV

( ) Solar Thermal

(X) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(1) Environmental

( ) Political

(2) Social

( ) None

( ) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, were there any available incentives for the development of such programs? Can you describe it? There weren't incentives for the implementation of this project.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

On 1998 a collaboration agreement was signed between Aena and the Spanish National Aerospace Institute ("Instituto Nacional de Técnica Aeroespacial", INTA) to foster the use of renewable energies and to introduce innovative technologies (solar thermal, photovoltaic and wind power) in Aena´s airports' network.

This framework of reciprocity, allowed Aena to count with an institution of technical prestige, such as INTA, capable of providing the necessary experience to guarantee the quality required for the development of this action.

Another collaborating entity was "Navegación Aerea", the air navigation service provider in Spain, in order to establish the viability of the project in relation to its possible interference with aircrafts operations.

Step 7: Which department is in charge of the renewable energy development in your organization?

Directorate of Planning and Environment of Aena

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

La Palma Airport is located next to the Atlantic Ocean and is exposed to the trade winds with a constant direction and intensity. These conditions facilitate an optimal performance for wind turbines. Therefore, the airport decided to install two 660 kW nominal power wind turbines, that started to generate energy on May 2003 and have not stopped since, making La Palma Airport the first airport in Spain powered by wind energy. The location of this small wind farm on the East zone of the airport does not interfere with the safe operation of the airport.

The energy supplied by these wind turbines is directly used to cover the airport´s electricity demand. However, in order to make full use of the whole energy generated by the wind turbines, La Palma Airport has signed a power supply contract with the local electricity supplier by which all power surplus generated by the airport is then sold

to the electricity supplier and can be resold to other customers. If the power generated by the wind turbines is not enough ‘per se’ to cover the airport’s energy demand, then the local supplier provides electricity to the airport.

The wind turbines facility at La Palma Airport is so successful that the airport is planning to increase the power range of the wind turbines to cover its full energy demand, thanks to the latest technology developments.

Estimated Cost and Financial mechanisms available: N/A

Images:


Taxi
Bus
P
Publico
Car Rental
Hertz
AVIS

Results (Environmental Benefit/Cost Benefit):

Shown below is the energy balance of La Palma Airport since the entry into service of the wind turbines. Globally,

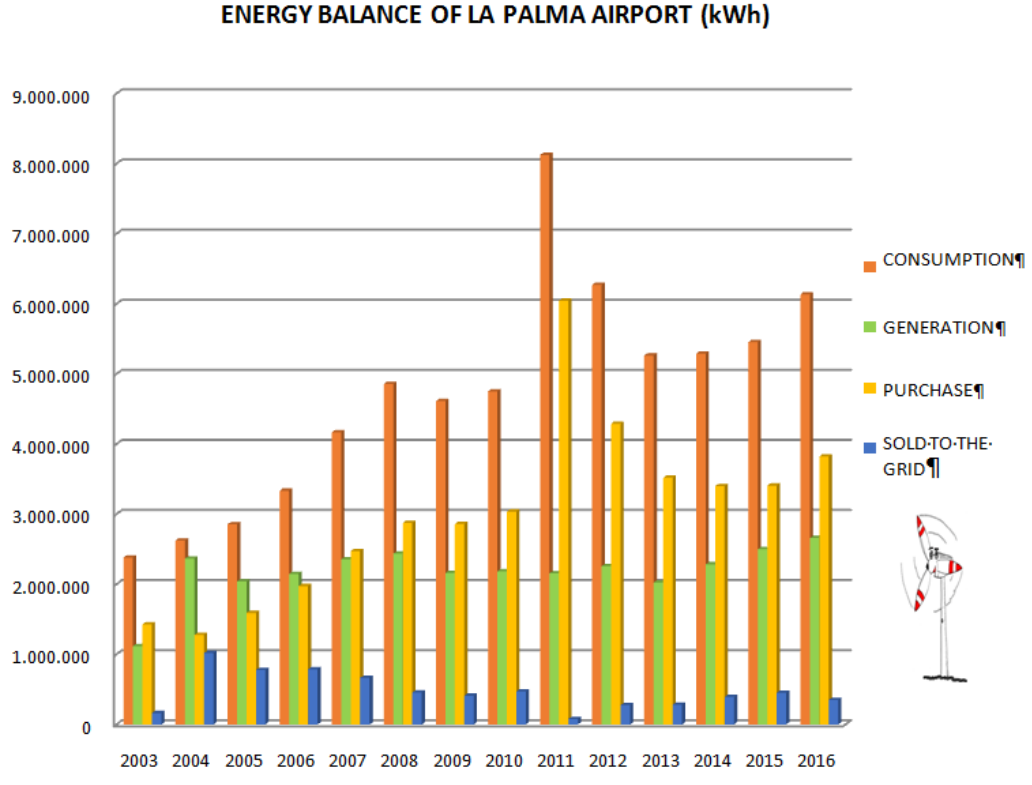
46.4% of the electricity consumption at the airport's facilities is covered by wind energy.

The generation of more than 30,000,000 kWh has allowed the airport to be less dependent on external power supply, which in the case of La Palma Island is derived from fuel burnt in a thermal power plant, and thus preventing the emission of more than 10,285 t CO^2

YEAR	ELECTRICITY CONSUMED	ELECTRICITY GENERATED	ELECTRICITY PURCHASED FROM THE	ELECTRICITY SOLD TO THE GRID (kWh)
2003	2,381,717	1,117,367	1,426,854	162,504
2004	2,623,936	2,366,896	1,275,596	1,018,556
2005	2,856,036	2,041,305	1,590,904	776,173
2006	3,334,726	2,148,791	1,974,160	788,225
2007	4,167,446	2,357,175	2,474,046	663,775
2003	2,381,717	1,117,367	1,426,854	162,504
2004	2,623,936	2,366,896	1,275,596	1,018,556
2005	2,856,036	2,041,305	1,590,904	776,173
2006	3,334,726	2,148,791	1,974,160	788,225
2007	4,167,446	2,357,175	2,474,046	663,775
2008	4,857,621	2,436,542	2,876,475	455,396

2009	4,613,204	2,163,220	2,860,342	410,358
2010	4,751,933	2,184,952	3,038,310	471,329

YEAR	ELECTRICITY CONSUMED	ELECTRICITY GENERATED	ELECTRICITY PURCHASED FROM THE	ELECTRICITY SOLD TO THE GRID (kWh)
2011	8,124,736	2,157,724	6,045,449	78,437
2012	6,271,186	2,257,912	4,289,157	275,883
2013	5,263,420	2,025,519	3,519,967	282,066
2014	5,290,859	2,285,360	3,399,393	393,894
2015	5,455,383	2,500,156	3,407,605	452,378
2016	6,134,676	2,660,905	3,823,924	350,153
TOTAL 2003-	66,126,879	30,703,824	42,002,182	6,579,127



Lessons Learned: Use of wind power at La Palma Airport meant a substantial change in the understanding of power generation in the airports, where reliability of electricity supply is core for safety in aircrafts movements.

Thus, initially it was not an easy project because the acquisition and installation of wind turbines at the La Palma Airport, entailed a great challenge to an organization accustomed to the supply of electricity through the conventional means. Even so, the project went ahead being La Palma airport suitable for the development of wind energy facilities, where trade winds provide high wind potential.

In conclusion, this is a project whose results have had a double benefit. On the one hand, an economic benefit, due the savings obtained by consuming the energy self-generated and on the other hand, an environmental benefit, by the use of a renewable source instead of other non-renewable resources, avoiding the emission of greenhouse gases.

Case study on Renewable Energy

Montreal Pierre Elliott Trudeau International Airport (YUL)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Lyne Michaud
Organization/Company	Aéroports de Montréal
Job Title	Assistant-Director, Environment and Sustainability
Email Address	Lyne.michaud@admtl.com
Telephone	514-633-2698
Airport *(Name and 3 Letter Code)*	Montreal Pierre Elliott Trudeau International Airport

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Closed Loop Geothermal Heat Pump for the Non Passenger Screening Vehicles Building

Timeframe (e.g., start and end month/year if applicable): 1 year (2016-2017)

Description: Construction of a new non passenger screening vehicles (NPSV) building which includes four closed loop geothermal wells of 604.8 ft. deep each amounting for a nominal cooling load of 12 tons.

Purpose: Build an environmentally friendly non-passenger screening vehicles building.

Step 3: Please identify which renewable energy technologies are used at your airport:

(x) Geothermal

( ) Solar PV

( ) Solar Thermal

Step 4: Please identify and prioritize the driver(s) for the renewable energy project.

Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(3) Political

(4) Social

( ) None

( ) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Commitment to develop an environmentally friendly non passenger screening vehicles building in a lot used as golf course by the municipality.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Yes.

Step 7: Which department is in charge of the renewable energy development in your organization?

Engineering and Terminal Maintenance

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

Taking into account the environmental, social and economic challenges, the geothermal energy feasibility study was conducted by ADM's engineers. A complete life cycle analysis including the payback, energy savings and return on investment calculations was presented to the executive committee.

Estimated Cost and Financial mechanisms available:

Initial Investment	165 000 $ CAD (for the geothermal system)
Annual Running Cost	4 855 $ CAD (energy and maintenance cost)
Annual Financial Savings	9 800 $ CAD

Images:

Results (Environmental Benefit/Cost Benefit):

- Energy benefits
- CO2 / GHG benefits
- Reduction of resource usage
- Community/Public Relations

Lessons Learned:

Geothermal energy is beneficial on a long term horizon. Initial cost is higher than other design options. However, the cumulative cost over the life cycle of the installation is the lowest. This was a pilot project and Aéroports de Montréal is looking ahead to incorporate this technology into various future projects.

Case Study on Renewable Energy

Mumbai International Airport (BOM)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Manisha Barrow
Organization/Company	Mumbai International Airport Pvt. Ltd.
Job Title	
Email Address	
Telephone	
Airport *(Name and 3 Letter Code)*	Mumbai International Airport (BOM)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Installation of roof top solar power plant at Airport premises in BOOT (Build, Own, Operate and Transfer) model.

Timeframe (e.g., start and end month/year if applicable):

Phase	**Locations**	**Capacity (kWp)**	**Date of Completion**
Phase 1	Terminal 1	650	Mar-15
Phase 2	Terminal 2 & Cargo Complex	413	Jun-16
Phase 3	Terminal 1 and Airside (CCR)	1,501	Mar-17
Total		**2,564**	

Description: MIAL being a Brownfield airport, there is shortage of vacant land for installing solar modules. Vacant rooftops of various buildings have been used for installation of solar power plant. The system has been installed on RCC rooftops, metal sheet roofs of Terminal 1, Terminal 2 and Cargo complex buildings.

Purpose: To continually improve the carbon footprint of airport operation and decision of aggressively pursuing solar power installation is a step to promote ecologically sustainable growth and also constitute a major contribution to the global effort to meet the challenges of climate change.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Environmental

(2) Social

(3) Economic

(4) Political

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

The major drivers were environmental and economics. The solar plant is helping in reducing carbon-dioxide emissions by about 2,600 tonnes annually. This is equivalent to planting 4 lakh mango trees and avoiding smoke emitted from 2,000 small cars in a year. This has also reduced our Electricity Bills.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

We have our internal team comprising of E&M, Environment, Procurement, Cargo, Terminal Operations involved in different stages of Project.

The system has been built under the 'build-own-operate-transfer' financial model. The solar plant is owned by a third-party investor and they sell green power to MIAL on per unit basis. The system was installed in 3 phases. Each phase is owned by different investor. The system installation is done by Sunshot Technologies who also taking care of the operation and maintenance of the solar power plant.

Step 7: Which department is in charge of the renewable energy development in your organization?

Engineering and Maintenance

Step 8: Please insert Text and Images of your project/case study below here: Decision-Making Process:

The project feasibility report is being prepared by Engineering and Maintenance department after thorough study of available area for solar installation. This is presented to top management through Environment department. Top Management approves the project for execution; accordingly MIAL procurement in consultation with E&M decides the suitable Agency for project.

Estimated Cost and Financial mechanisms available:

-Per MWp cost varies from Rs. 6 to 8 Crores depending on site constraints and unique design specifications.

-Project installed under BOOT model where, third party invest in the project and operate the plant as per MIAL requirements, however, MIAL make the payment on monthly basis to investor based on generation and power purchase agreement.

Images:

Results (Environmental Benefit/Cost Benefit):

- The solar plant is helping in reducing carbon-dioxide emissions by about 2,600 tonnes annually
- Reduced the electricity demand from distribution company which result in net saving in energy cost by approx 1.8 Crore annually.

Lessons Learned:

- We should always go for the latest PV solar panels having maximum efficiency.
- The roof top solar plants should be planned at the time of construction of the building. This will enable us to get maximum benefit.

Case Study on Renewable Energy

Vienna International Airport (VIE)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	DI Stefan Kovacs
Organization/Company	Vienna International Airport
Job Title	Facility Management Dept.
Email Address	s.kovacs@viennaairport.com
Telephone	0043-1-7007-22392
Airport *(Name and 3 Letter Code)*	Vienna International Airport (VIE)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Installation of 3 PV at VIE

Timeframe (e.g., start and end month/year if applicable): 2016/2017

Description:

1st Unit: roof mounted on object 836, start-up at 22nd of June 2016, 236kWp

2nd Unit: roof mounted on object 239 (Hangar 7), 22nd of June 2016, 273kWp

3rd Unit: roof mounted on object ACC-Ost, start up in October 2017, 715kWp

Purpose: To show our efforts on environmental issues and to reduce VIE´s CO2-footprint.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(X) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(6) Economic

(3) Environmental

(1) Political

(2) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it? VIE has not, and will not get any incentives for installing photovoltaics.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with. No.

Step 7: Which department is in charge of the renewable energy development in your organization? The facility management department is in charge of all supply and disposal issues, and the power supply – and in this case the PV – is part of it.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:N/A

Estimated Cost and Financial mechanisms available:

1st Unit: EURO 400.000

2nd Unit: EURO 430.000

3rd Unit: EURO 1.100.000

Images: N/A

Results(Environmental Benefit/Cost Benefit): amortization time >18years

1st Unit: -180 t CO2/a

2nd Unit: -200 t CO2/a

3rd Unit: -500 t CO2/a

Lessons Learned:

The big challenges are the building permit and the costs of a PV plant on the airport. There are lots of regulations, which have to be fulfilled (working regulation, fire regulation, evacuation regulation, electrical regulation). All these requirements can be achieved, but the side effects are the rising costs of such PV plant. There are also an important issue which has to be careful take into consideration, as the direct glare of pilots and the control tower. These two issues show, that not every roof on an airport can be used for a PV power plant.

Another big cost issue is the connection to the electrical network. If the way to the next input station is too far or difficult to reach (long cable ways, road works, cable ducts) the costs will be higher for such PV plant. These costs can be so high, that the payback period is too long for such investment. The main rules for such PV construction are" the substructure must be simple and cheap - the roof space must be used very efficient (max. capacity kWp) - the ways to the electric network must be short".

Case Study on Renewable Energy

San Diego International Airport (SAN)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Brendan Reed
Organization/Company	San Diego County Regional Airport Authority
Job Title	Director of Environmental Affairs
Email Address	breed@san.org
Telephone	619-400-2785
Airport *(Name and 3 Letter Code)*	San Diego International Airport (SAN)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: SAN Solar Photovoltaic Project (Phases 1 & 2) Timeframe (e.g., start and end month/year if applicable): 2014-2017

Description: In total, approximately 5.5 megawatts of solar photovoltaic arrays were installed on building roofs and in parking lots

Purpose: The project's purpose was to reduce the San Diego International Airport's greenhouse gas emissions (Scope 2), while reducing long-term utility costs and improving SAN's resilience to utility service disruptions.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(X) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(4) Political

(5) Social

(6) None

(3) Other _Resilience_____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

As a public agency in California, greenhouse gas (GHG) emissions are an increasingly important topic in regards to community concerns and state regulations. Since electricity use is the largest contributor to airport-controlled GHG emissions, renewable electricity represents a significant opportunity to reduce these emissions. In addition, the Airport spends approximately $9 million annually on electricity costs, with rates expected to rise considerable over the next 10 years. The new solar panels (though the Power Purchase Agreement) lock in SAN's electricity rates for a 20 year term, helping to stabilize rates in the long term.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

A variety of internal and external stakeholders were engaged as part of the Solar PV project's development. Key internal stakeholders included airport departments, especially environmental affairs, finance, real estate, facilities development/engineering, and facilities management. Externally, SAN engaged the utility company (for interconnection agreement), a local nonprofit organization (who administers the state incentive program), and the regional planning agency's Environmental Working Group (to share project highlights & benefits).

Step 7: Which department is in charge of the renewable energy development in your organization?

The Environmental Affairs Department is the lead in developing and implementing the Airport's Strategic Energy Plan, which establishes renewable energy priorities and targets.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: SAN issued a formal Request for Proposals to select a contractor to design and install the onsite solar photovoltaic systems.

Estimated Cost and Financial mechanisms available: While SAN did consider an option to purchase the system outright, the Airport eventually decided to enter into a Power Purchase Agreement with a third-party, who would install, operate, and maintain the system for a 20-year term. In exchange, the Airport would purchase all of the system's generated electricity at a flat rate.

Images:

Results (Environmental Benefit/Cost Benefit): With the new solar photovoltaic arrays, SAN is annually generating approximately 9.3 million kWh of renewable electricity on site (about 20% of the Airport's total energy consumption).

Lessons Learned: Important lessons learned include (1) carefully siting solar energy systems due to their long-term nature, (2) quantifying expected and actual project benefits to help inform and reassure decision-makers, and (3) communicating early and often with the utility company on project details and interconnection needs.

Case Study on Renewable Energy

Darwin International Airport (DRW)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Rhett Nothling
Organization/Company	Northern Territory Airports
Job Title	Head of Projects
Email Address	Rhett.nothling@ntairports.com.au
Telephone	+61 437 984 235
Airport *(Name and 3 Letter Code)*	Darwin International Airport DRW

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Darwin International Solar

Darwin Solar Stage 1

Timeframe (e.g., start and end month/year if applicable):

Start date December 2015 - completed May 2016

Description:

Airport Development Group is 'lighting the way' towards a more sustainable future.

In May 2016, Darwin International Airport (DIA) flicked the switch on its new 4MW (megawatt) photovoltaic (PV) solar array, which now provides a significant proportion of the airport's power.

Purpose:

Airport Development Group has made a long term commitment to using renewable energy across its three Northern Territory based airports in Darwin, Alice Springs and Tennant Creek. The Board is mindful of the contribution the aviation industry makes to greenhouse gas emissions, and is keen to lead the way for other airports – both national and international – by reducing its carbon footprint.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Economic with Economic and Environmental being equal

(2) Environmental

(3) Innovation

(4) Political

(5) Social

(6) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, were there any available incentives for the development of such programs? Can you describe it?

DIA's ability to manage and control ongoing costs together with the environmental management and sustainability benefits were the key drivers for this project. The solar farm sits upon a previously cleared area within the OLS (Obstacle Limitation Surface) which needed ongoing maintenance and was problematic due to invasive weeds and pioneer species. The clearing and stabilisation of the site removed the habitat for invasive weed species and the associated surface drainage works moved water off site in a controlled manner. Work included earthworks, storm water drains, access roads and solar modules, with the construction being completed in an impressive period of only five months.

In addition the land was not required for alternative aviation activities, and therefore able to be repurposed, giving both economic return and environmental benefits. Hence the two equal and key drivers are environmental and economic aspects.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Darwin Solar Stage 1was a team effort across Darwin International Airport project managers environment teams, external consultants (Cat Projects) and Head Contractor (UGL) for the project delivery component.

CAT Projects is a Northern Territory based indigenous-owned company which conceived the development and acted as owner, engineer and project superintendent. Engineering and property Services Company UGL engineered, procured and constructed the solar farm.

Extensive negotiations were undertaken by DIA with the Australian Defence Force to ensure compliance with orientation of the PV Array as well as detailed agreements with the local Power and Water authorities to ensure the correct power management strategies were in place to accommodate the array.

Step 7: Which department is in charge of the renewable energy development in your organization?

Infrastructure, Planning and Environment with the project being delivered by DIA's Project Team.

Step 8: Please insert Text and Images of your project/case study below here:

Images: attached at the end of the document. Additional high res images are available upon request.

Click here to view a short film on our solar project http://www.darwinairport.com.au/corporate/c-environment#accordion-0-2

Decision Making Process

DIA is always mindful of its energy use as well as forecasted demand for power associated with future development projects. The key criteria for decision making in this significant capital expenditure was motivated by DIA's ability to manage and control future ongoing costs associated with its energy use.

Some considerations in the decision making process included:

- Project and site selection that would provide maximum benefit and capital return (roof top install vs in ground in situ installations);
- Maximising land use and in this case land considered to have minimum or limited commercial value for development (due to location);
- Maintaining control over costs associated with ongoing energy costs forecast to increase significantly;
- Reduce DIA's carbon footprint in alignment with other energy saving project initiatives;
- Demonstrate commitment to sustainable investment;
- Direct capital costs to DIA's specific initiative and avoid 3rd party substation upgrades to support the airport and airport precinct;
- Reducing and managing peak demand periods; and
- Continuous improvement on similar successful project initiatives recently completed on other Northern

Territory Airport's sites.

Estimated Cost and Financial mechanisms available:

Northern Territory Airports is one of the Territory's largest private sector investors, with its parent group Airport

Development Group owning and operating airports in Darwin, Alice Springs and Tennant Creek.

Its pioneering investment in solar energy is unparalleled for an airport operator in the southern hemisphere. The total value of Darwin Solar Stage 1 was over $10 million and investment in the overall project will be $13million upon completion. The solar array in Darwin is entirely financed by private sector investment and is expected to reduce the airport's power bills by $2million per annum based on current peak tariff rates.

Results (Environmental Benefit/Cost Benefit):

Not only do the environmental benefits manifest with a 25% reduction in carbon emissions from stationary energy, the significant investment of capital towards this project, enables DIA to hedge the exposure of the airport to fluctuations in electricity prices thus providing greater certainty for the broader airport community and interested investors, partners and stakeholders.

Moreover the project provides a basis for the Darwin International Airport Board and Executive to focus attention on energy and how it works as an enabler. This new provision of energy has boosted development for Darwin International Airport and the broader user group and will continue well into the future.

Upon completion of Darwin Solar Stage 2, the system is forecast to meet up to 100 per cent of the airport's peak energy demand in the middle of the day and to generate 25 per cent of the airport's overall energy needs. It will produce electricity equivalent to the consumption of 1,000 average Australian households.

Lessons Learned:

The challenges with a project such as this, and particularly one developed entirely by the airport, are extensive. Darwin International Airport is a joint-user airport with active military users, including international military partners, and a strategic facility as part of Australia's Defence Infrastructure. As such, this project required a level of stakeholder management and engagement unparalleled by other civilian airport projects in Australia.

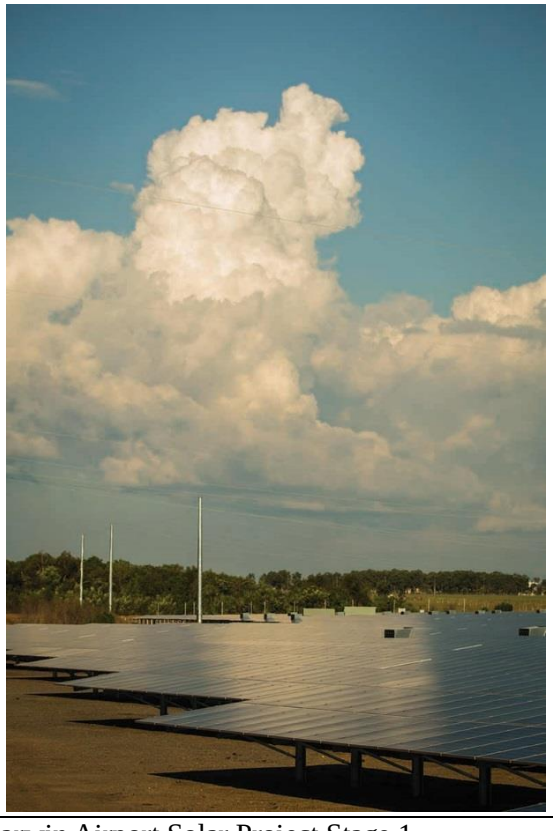
For example, sophisticated glare and glint monitoring tools developed specifically for the project's unique requirements were used; extensive consultation and planning throughout the project, and technical elevation of the design was required.

An environmental plan which accounted for the joint-user status was developed, with special consideration of the land being used. As a former wartime airbase and considering the history of Cyclone Tracy, there was a risk of environmental waste being present on the site. As such, ground penetrating radar equipment was used to judge the potential risks of repurposing the land for solar.

To further enhance the environmental benefits of the project, all millings from a previous Runway Resurfacing Project were re-utilised at the solar farm. This highly innovative approach will prevent erosion due to the proposed sediment control and prevent weed growth in the area. By compacting the millings and re-using them on site, DIA also eliminated the need to further store the water on airport land.

The environmental considerations which led to the development of such measures is particularly pertinent considering the airport's close proximity to urban Darwin and conservation buffer zone around Marrara swamp.

The environmental stewardship demonstrated by Darwin International Airport for Darwin Solar Stage 1 further enhances the value of this significant project.

	
Darwin Airport Solar Project Stage 1	Darwin Airport Solar Project Stage 1, before and after


LIGHTING
THE WAY

Case Study on Renewable Energy

East Midlands Airport (EMA)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Adam Freeman
Organization/Company	Manchester Airport Group
Job Title	Environment Advisor
Email Address	Adam.freeman@manairport.co.uk
Telephone	+44-161-489-3595
Airport *(Name and 3 Letter Code)*	East Midlands Airport, EMA

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:

Wind turbines at East Midlands Airport

Timeframe (e.g., start and end month/year if applicable):
Installed 2011

Description:

Two 45 metre 250kW wind turbines, generating 5% of the airport's electricity needs and reducing annual carbon emissions by 150 tonnes CO_2 each year.

Purpose:

Contribute to the airport company's commitment to carbon neutral operations from 2012 by producing renewable electricity on site.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

( ) Solar PV

( ) Solar Thermal

(X) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(4) Political

(5) Social

( ) None

(3) Other Securityoverenergysupplyandcost

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

In 2006 East Midlands Airport committed to make its ground operations carbon neutral by 2012. The wind turbines helped the airport achieve this target. Whilst the airport's priority is to reduce energy demand, the wind turbines enable the generation of low carbon electricity on site. The project is supported by the UK Government's feed-in-tariffs and provide increased security over both energy supply and cost, generating attractive returns on investment (Internal Rate of Return >11%).

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

A range of stakeholder engagement was necessary to deliver the project.

Internal consultation was extensive, particularly with our engineering and air traffic control teams – who needed to ensure compatibility with electrical networks, and no adverse impacts on radar or communications and that the turbines would not be an obstacle to safe aircraft operations.

Externally, our local community were consulted and found to be supportive of the proposal – they had been engaged with our environmental strategy and carbon neutral commitment through our community relations programmes. Extensive engagement was also needed to demonstrate no risk to aviation safety to the regulator, the UK Civil Aviation Authority.

Step 7: Which department is in charge of the renewable energy development in your organization?

Asset Management

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

In 2006 the airport committed to make its ground operations carbon neutral by 2012. This target was the first of its kind from a UK airport, and followed extensive public consultation on the airport's Master Plan. The plan set out our ambition to become more energy efficient, before sourcing renewable – low carbon – energy and fuel, and then compensating for residual emissions through the purchase of carbon offsets.

After working with wind turbine manufacturers, utility companies and the Civil Aviation Authority to demonstrate a business case for investment – a capital project of £1.1m was approved.

Estimated Cost and Financial mechanisms available:

Over its 20 year life time, the project provides an 11% internal rate of return.

Images:

Results (Environmental Benefit/Cost Benefit):

- Providing certainty over secure energy supply, at a known and stable cost
- Generating 5% of airport's electricity requirements from on-site renewable technology
- Reducing annual carbon emissions by 150 tonnes CO_2
- Highly visible statement of the airport's commitment to sustainability.
- Supporting education initiatives by the airport, providing case studies for schools and colleges using the on-site education facility.

Lessons Learned:

- Local community more supportive of the project than expected
- Early engagement with regulator is key to success

Case Study on Renewable Energy

Stockholm Arlanda Airport (ARN)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Henrik Fröjd
Organization/Company	Swedavia Energi AB
Job Title	Energy production engineer
Email Address	henrik.frojd@swedavia.se
Telephone	0734054209
Airport *(Name and 3 Letter Code)*	Arlanda (ARN)

Step 2: Please provide the following basic information of your Project/Case Study: Project/Case Study

Title: Aquifer storage for heat and cold production at Arlanda airport Timeframe (e.g., start and end month/year if applicable): 2006-2008

Description: Project with the aim to make storage of heat and cold for the airport possible, and therefore decreasing the production peaks and need for extra cooling machines. Mainly used for cooling.

Purpose: Storage of heat and cold for the airport

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

( ) Solar PV

( ) Solar Thermal

( ) Wind

(x) Other Aquifer

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Economic

(1) Environmental

(4) Political

(4) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentive for the development of such programs? Can you describe it?

Company environmental goals with the aim to decrease CO2 emissions. Need for extra cooling capacity due to more buildings / larger area to cool and increased traffic / more people at the airport.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Not sure.

Step 7: Which department is in charge of the renewable energy development in your organization?

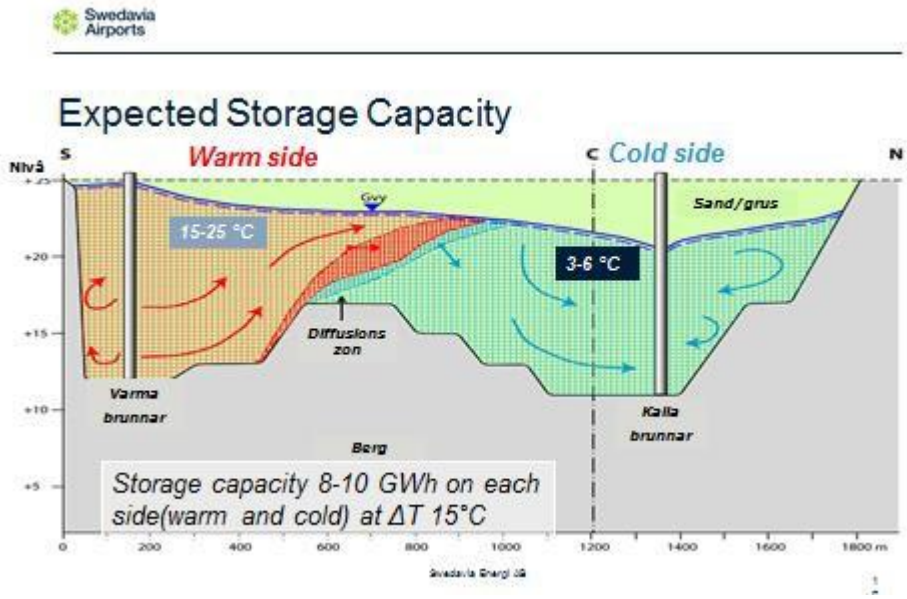
Corporate Engineering Department – Energy - Comfort

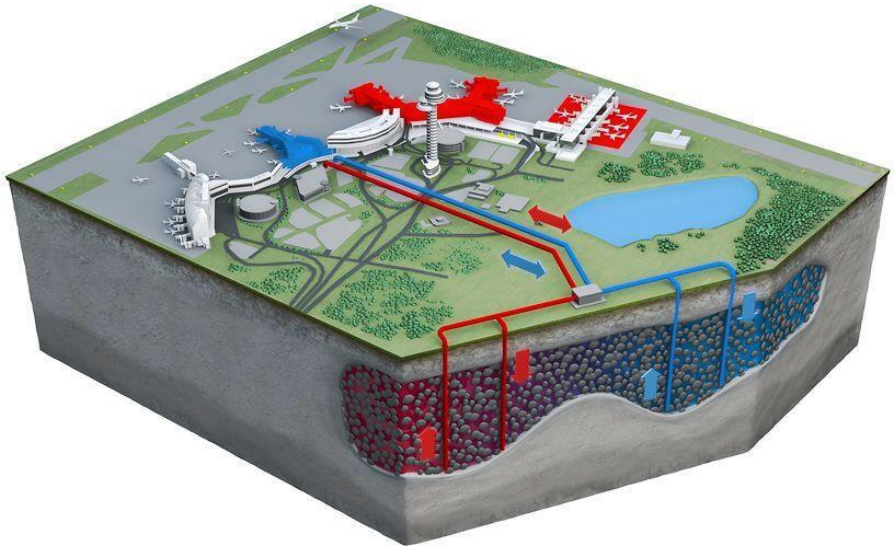
Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: Not sure.

Estimated Cost and Financial mechanisms available: 52 MSEK

Images:





Results (Environmental Benefit/Cost Benefit): Direct payback time approx. 8 years (annual savings about 7 GWh /

7 MSEK). Service costs approx. the same as for cooling machines with equal capacity.

Lessons Learned: Sand filter installed after problems with sand damaging heat exchangers. Real capacity is somewhat less than expected. Low temperature heat less useful than expected. But overall a good investment.

ICAO

ENVIRONMENT

Waste Management at Airports

ECO AIRPORT TOOLKIT
Case Studies

Waste Management at Airports

Annex 1. Sample Outline for a Recycling and Waste Reduction Plan

a. Facility Description and Background

1) Background information about airport
2) Scope of existing recycling programs
3) Airport's current waste management program
4) Drivers for implementing/maintaining a recycling program
5) Description and inventory of recycling infrastructure (both on/off airport)
6) Description of the airport's current solid waste recycling, reuse, and waste reduction efforts
7) Description of program performance

b. Waste Audit

1) The annual quantity and composition of generated MSW and CDD debris
2) The sources and activities that generate waste
3) The generators (owners and facilities/areas) of various waste streams

c. Review of Recycling Feasibility

1) Describe the technical and economic factors that currently affect the airport's ability to recycle
2) Federal, state, or local guidelines or policies
3) Other incentives for implementing/maintaining a recycling program
4) Identify logistical constraints

d. Operation and Maintenance (O&M) Requirements

1) Describe waste handling, and the parties responsible for each area and waste stream.
2) Identify department/ section/organization responsible for implementation of each aspect of the airport's recycling program, and their roles and responsibilities

e. Review of Waste Management Contracts

1) Describe current contracting for waste management at the airport
2) Describe how existing contracts encourage or impede the purchase/use of environmentally-preferred products
3) Identify tenant leases and service contracts with corresponding expiration, extension, and/or renewal dates
4) Describe how waste handling and recycling is funded

f. Potential for Cost Savings or Revenue Generation

Presents recycling program recommendations developed following review of the preceding work, and compares the cost of landfilling waste with recycling, composting, or reuse. This is accomplished through financial analysis of the overall waste management program, the current airport recycling program, and potential recommendations that will enhance and broaden the program.

g. Plan to Minimize Solid Waste Generation

1) At a minimum, document the airport's program to recycle paper (newspaper and magazines), plastic bottles and aluminium cans, and plastic cups
2) Present the airport's plan for a comprehensive approach to reduce the amount of waste being disposed of in landfills. Objectives and targets should be established.
3) Consider updated arrangements/contracts/leases between the airport and tenants, new development specifications (to include containers and space for material collection, sorting, and recycling), and new purchasing policies/requirements
4) If aspects of the plan require capital improvements, these should be referenced in the plan and included in the Airport Capital Improvement Plan
5) Describe any plan recommendations that may conflict with existing plans and programs
6) Discuss how recycling will be implemented as part of new development projects; include the information and timeframe needed to meet the goals
7) Discuss how the airport will track and report on the recommendations, and how this will be reviewed
8) Description of any future program enhancements, if any are known
9) Earlier sections may have identified constraints to improving recycling performance that are outside of the airport's control; describe conditions that will trigger re-evaluation
10) Describe planned efforts for education and outreach

Annex 2. Case studies on waste management at airports (Draft)

ECO AIRPORT TOOLKIT

Auckland International Airport: Waste Management

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Helen Jenkins
Organization/Company	Auckland Airport
Job Title	Environment and Sustainability Manager (Acting)
Email Address	Helen.jenkins@aucklandairport.co.nz CSRreporting@aucklandairport.co.nz
Telephone	+649 22 407 9820

Airport *(Name and 3 Letter Code)*	

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:

Timeframe (e.g., start and end month/year if applicable):

Description:

Purpose:

Step 3: Please identify which waste processing is/are used at your airport:

(√) Recycling

( ) Waste Recovery (e.g Waste to Energy)

(√) Incineration

(√) Landfill

(√) Other - Off site composting _____

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(5) Political

(4) Social

(3) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Two main drivers – improve diversion of waste from landfill, and the economic driver to reduce the tonnage of waste requiring sterilisation while maintaining strict biosecurity requirements.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

Organic waste – Green, with pictogram and description in English "Organic waste"

Mixed recyclables – Yellow, with pictogram and description in English "Comingled recyclables"

General waste – Red, with pictogram and description in English "General waste"

Colour coding is not based on national regulation. International harmonization would be helpful.

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

Internal stakeholders – Cabin staff, Ground handling staff, Our waste management contractor

External stakeholders – the Biosecurity regulator, known as MPI

Step 8: Which department is in charge of waste management in your organization?

Airport Operations are in charge of waste management.

Step 9: Please insert Text and Images of your project/case study below here:

Enclosed as hyperlink to Case Study:

Green_Airports_Recognition_2018_Auckland Airport entry.doc

Decision-Making Process:

Estimated Cost and Financial mechanisms available:

Images:

Results (Environmental Benefit/Cost Benefit):

Lessons Learned:

ECO AIRPORT TOOLKIT

Christchurch International Airport: Project Coffee Cup

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Brodie Akacich
Organization/Company	Christchurch International Airport Limited
Job Title	Sustainability Manager
Email Address	Brodie.Akacich@cial.co.nz
Telephone	+64 273579737
Airport *(Name and 3 Letter Code)*	Christchurch International Airport - CHC

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Project Coffee Cup

Timeframe: May 2017 - Ongoing

Description:

Christchurch Airport's Sustainability Strategy is centered around the Maori concept of kaitiakitanga or guardianship, placing emphasis on caring for the environment for future generations. A key pillar of our strategy focuses on Waste and sets a firm commitment to divert more than 60% of our waste away from landfill by 2025.

Key to achieving our target is reducing the contamination of recycling streams collected from public areas. The most common contaminant found are disposable coffee cups, either originating from the terminal café's or offsite.

This is a result of labelling confusion, as it is common for most disposable cups to be branded with ecolabeling. While this labelling may be correct, the coffee cups are not recyclable and enter our recyclable waste streams. This contaminates good quality recyclables, and with no viable composting options all of these cups and contaminated recyclables must go to landfill.

To address this problem, we set out to the directly influence two areas we could create change in.

1. Reduce the number of disposable cups used by our staff. Estimates suggested we were using:
    - 440 cups/week, ~1m^3 or ~5kgs of waste
    - 21,120 cups/year, ~40m^3 or ~300kgs of waste

    Staff were given a bespoke Christchurch Airport coffee cup with messaging explaining they were reducing their personal waste footprint by 3.6kgs/yr

2. We developed bespoke bins for disposable coffee cups. They look like giant coffee cups and themed and labelled to avoid confusion. Studies indicate the waste behaviors of people are driven by convenience, so our plan was to use the bins resembling a coffee cup next to recycling stations.

Within one month, terminal recycling rates increased by 7% and have remained above previous figures. Staff use of reusable cups also increased, with ~75% of staff now using reusable cups at least occasionally, up from ~52%.

Purpose:

This project had two key objectives

1. Encourage our staff (250 FTEs) to use reusable coffee cups.
2. Reduce public confusion regarding where to put used coffee cups.

Step 3: Please identify which waste processing is/are used at your airport:

(√) Recycling

( ) Waste Recovery (e.g Waste to Energy)

( ) Incineration

(√) Landfill

(√) Other: Offsite organic composting

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(1) Environmental

(5) Political

(2) Social

(4) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Waste is a key pillar of Christchurch Airport's Sustainability Strategy with Recycling (Waste Diversion) rates being linked to ambitious performance targets to increase the recycling rates from our terminal facilities.

The key drivers behind our efforts have been primarily driven by the companies desire to be a good public citizen. We understand our operation creates a waste footprint therefore we proactively strive to reduce the impact (Environmental) of that footprint. Also, the general public expect that large public facilities provide public place recycling thus there is a social driver behind our waste efforts as well.

Christchurch Airport has received grants historically from organisations such as LoveNZ and WasteMINZ which contributed to the increase of public place recycling bins throughout the terminal. More recent projects such as Project Coffee Cup and the Waste Champions initiatives have been resourced entirely by Christchurch Airport.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

International harmonisation of bin colours would be extremely beneficial as it would ensure consistency for the travelling passenger. Colours used at Christchurch Airport are consistent with New Zealand standards.

Red – General Waste

Yellow – Co-mingled recycling

Blue – Glass

Green – Organics (food waste)

Coffee Cups – Brown (coffee)

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

This project had two key objectives

1. Encourage our staff (250 FTEs) to use reusable coffee cups.
2. Reduce public confusion regarding where to put used coffee cups.

Boundaries of this project were Christchurch Airport offices and the Terminal.

Stakeholders included airport staff, café's and our cleaning contractor OCS.

Our social media efforts to promote the bins received 341 likes and 32 shares (including the Deputy Mayor) in a short period of time. Terminal cafés actively promoted their use to the public to reduce confusion over which bin to use. Furthermore, cleaning staff reported significantly lower rates of contamination in recycling bins from coffee cups, which resulted in the higher diversion rates.

Since implementing this innovative solution, we have been approached by several entities asking for advice on how to implement a similar system. To date we are aware that Brisbane Airport Corporation and Mt Ruapehu ski field have adopted similar versions of our bins.

This project also served as a catalyst for Terminal tenants becoming more involved in our waste programme. Since implementation, our team has established a Waste Champions group of representatives from all tenants. The purpose of this group is to share information and inform tenants of any new waste procedures. It also serves as a recognition forum, recognising and rewarding members for their efforts.

Step 8: Which department is in charge of waste management in your organization?

Responsibility for waste management is shared between the Terminal Management team and the Sustainability team

Step 9: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

Bins: The decision-making process for this initiative was made at the senior management level (Sustainability Manager) and did not need Executive (General Manager/CEO) approval. The concept was brought to life through a collaborative approach involving the Terminal Team (Airport Services and our cleaning contractor) and our marketing design team (artwork and social media).

Coffee Cups: This initiative was lead by the Sustainability team with the support of our Marketing design team to develop bespoke artwork as part of the launch of the Sustainability Strategy. The reusable cups were selected and designed using New Zealand based companies and iconic species of plants native to the South Island of New Zealand.

Estimated Cost and Financial mechanisms available:

250 Coffee cups were purchased in bulk at a negotiated rate to reduces the total cost of the initiative. Concurrently local artists were commissioned to design bespoke artwork to go on the coffee cups to make them attractive to staff.

The Coffee Cup bins were selected based on availability and look of the bin. The aim was to select a basic bin that looked like a disposable coffee cup and then have them wrapped in a bespoke design. Three Bins were purchased for $200 ea and wrapped in a bespoke plastic skin for and additional $100 (total - $900 for three bins).

Images:

Coffee Cups:

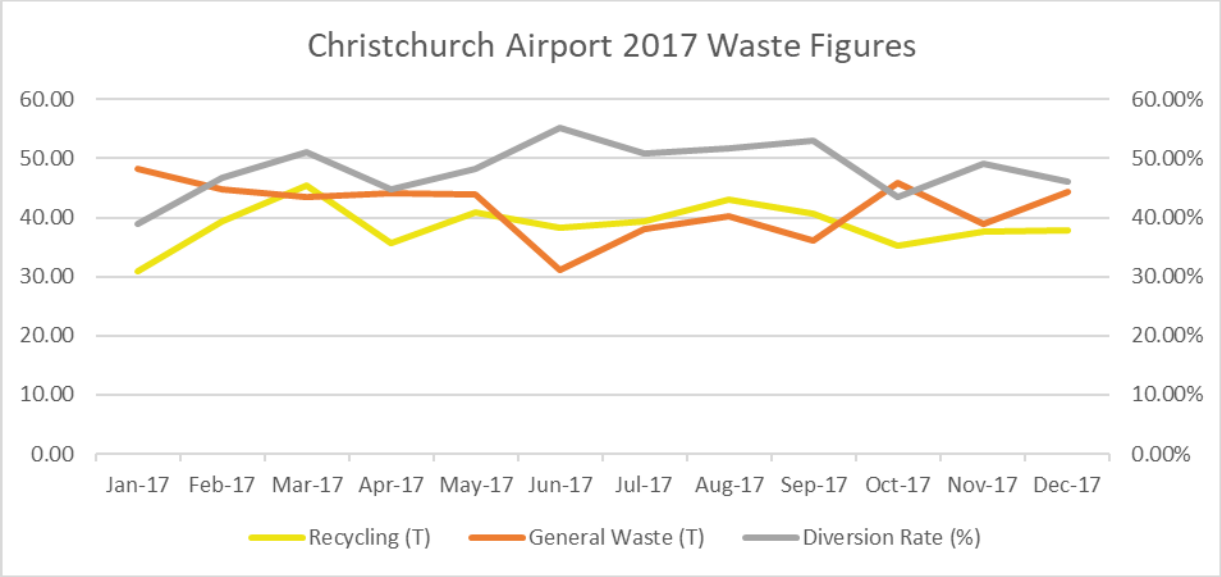

SUSTAINABILITY STARTS
CHRISTCHURCH AIRPORT
CHAMPIONING
SUSTAINABILITY

Bins:


WASTE
RECYCLABLES
MIXED GLASS
UNSURE – put it here
NO FOOD OR LIQUIDS
NO FOOD OR LIQUIDS
Coffee Cups
AIRPORT

Results (Environmental Benefit/Cost Benefit):

The main benefit tracked as part of this initiative has been Waste Diversion percentage (% of total recycling collected). Project Coffee Cup was launched at the end of May in 2017, immediately it was observed that the bins were being used for Coffee cups and that recycling bins were less contaminated. The effect of this was significant – less recycling was being rejected therefore recycling yield (tonnes) and Diversion Rates (%) increased in June to >50%.



Lessons Learned:

Several lessons were learnt from this initiative:

Cups: Whilst the design and concept were embraced by staff, the cups selected were difficult to seal and usage has fluctuated as a result. Some staff have since purchased an easier sealing cup to address the issue. Our recommendation would be to approach staff with a range of cups to gauge preference prior to bulk ordering.

Bins: The disposable coffee cups collected by these bins can only be disposed of at a landfill facility as there are no commercial facilities on the South Island of New Zealand that will accept disposable coffee cups. However it has been observed that the public will used this bins as general waste bins on occasion which would cause collected cups to be rejected if they were going to a recycling facility. Our recommendation would be to ensure these bespoke bins are paired with general waste and co-mingled bins as shown in the above picture to avoid this issue.

ECO AIRPORT TOOLKIT

Brisbane International Airport: Aerosol Donation Program

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an ECO Airport Toolkit, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 Airport Planning Manual, Part 2, Land Use and Environmental Management. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Wendy Weir
Organization/Company	Brisbane Airport Corporation Pty Ltd
Job Title	Environment and Sustainability Manager
Email Address	Wendy.weir@bne.com.au
Telephone	+617 734063268
Airport *(Name and 3 Letter Code)*	Brisbane Airport BNE

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: **Aerosol donation Program**

Timeframe (e.g., start and end month/year if applicable): October 2017 onwards

Description:

A need for the installation of a Liquid, Aerosol and Gels (LAGs) waste station was identified during a passenger facilitation assessment to reduce congestion through the security check point at the Brisbane International Terminal. Any LAGs confiscated by security at the screening point have to be incinerated under Australian legislation.

Opportunities were identified to not only reduce passenger congestion but to capture LAG waste before the check point and divert it from incineration. The project identified an opportunity to allow further segregation than the usual 'general waste' and 'comingled' recycling streams.

A trial to reduce aerosol waste from Brisbane Airport started in co-operation with charity GIVIT in late 2017. This initiative has been driven by BAC staff who became dismayed by seeing aerosols, often full, going to incineration.

So far more than 180 items have been donated via the initiative. Through GIVIT these items are now reaching charities and going to needy people experiencing homelessness or those living in hostels or safe houses.

This trial is a wonderful opportunity for airport operators and local charities to work together to reduce waste and to make a difference in the lives of underprivileged members of our community.

Several organizations were involved in the project including BAC, SecureClean (BAC Cleaning Contractor), and GIVIT (Local charity).

Purpose:

This project is the first of its kind in an Australian airport. The environmental benefits are that perfectly usable aerosols can be diverted from incineration (whilst ensuring compliance with legislation) with the additional social benefit that vulnerable and disadvantaged people can use them instead. By demonstrating this process is successful, it can be improved and replicated across all Australian international airports.

Step 3: Please identify which waste processing is/are used at your airport:

(X) Recycling/ repurposing

( ) Waste Recovery (e.g Waste to Energy)

( ) Incineration

( ) Landfill

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(5) Economic

(2) Environmental

(6) Political

(1) Social

(4) Regulatory

(3) Other: Staff morale

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Operational: To reduce congestion at the security check point by encouraging passengers to dispose of LAGS prior to the check point and simultaneously reduce the amount of waste that needs to be incinerated.

Social: To support underprivileged and needy members of the community.

Environmental: To reduce the waste of aerosols and stop them going to incineration.

Staff morale: Improve morale of airport staff concerned by the waste of aerosol products.

Regulatory: This project will be used as a flagship to commence lobbying the Australian Government to enable airports to donate good quality aerosols surrendered at security check points to charity if passengers give their consent.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

Red: general waste (as per Queensland Government colour system)

Yellow: comingled recycling (as per Queensland Government colour system)

All other colours (green, blue and purple) were chosen to be distinct from the other colours.

International harmonization would be good although would take time to be effective.

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

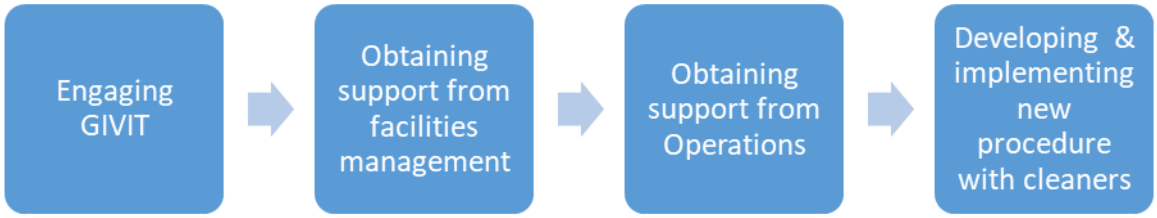
Yes to both. Firstly finding a charity that could accept the aerosols had to be found and convinced that the process could work and that health standards would be upheld. Internal stakeholders had to be satisfied that existing cleaning contractors could source separate aerosols from rubbish (if passengers do not source separate correctly) and arrange delivery of the aerosols to the charity. Passenger facilitation and security teams had to be convinced that the new LAGS waste station would be effective and not introduce delays to passenger processing.

Step 8: Which department is in charge of waste management in your organization?

Facilities Management

Step 9: Please insert Text and Images of your project/case study below here:

Decision-Making Process:



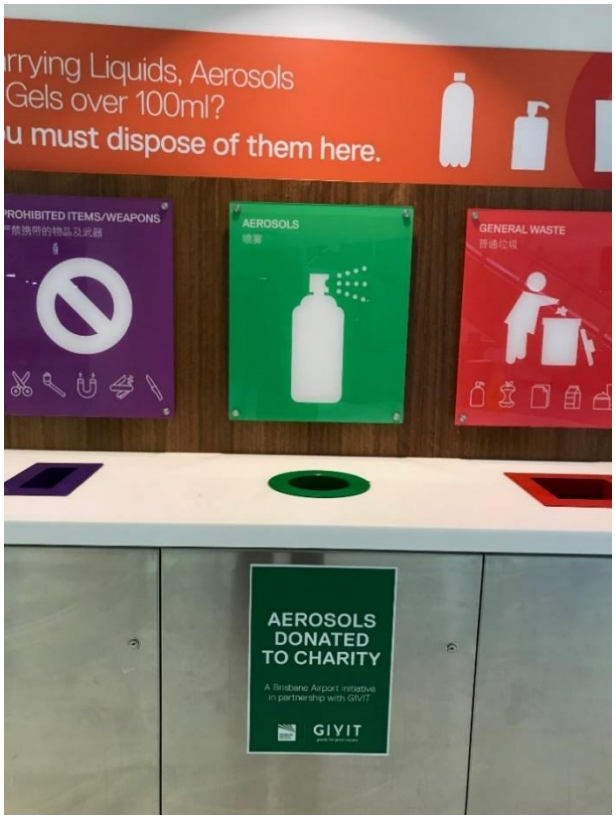
Estimated Cost and Financial mechanisms available:

The cost for separating aerosols and delivering to the GIVIT warehouse is included in the existing cleaning contract. No additional costs are incurred as a result of this project.

The new LAGS waste station cost $26,000 AUD to design, construct and install. Half of this cost was due to connecting drainage to the sink, enabling passengers to tip out liquids prior to disposing of bottles.

Images:


Carrying Liquids, Aerosols
or Gels over 100ml?
You must dispose of them here.
PROHIBITED ITEMS/WEAPONS
AEROSOLS
GENERAL WASTE
AEROSOLS
DONATED
TO CHARITY
GIVIT


rrying Liquids, Aerosols
Gels over 100ml?
u must dispose of them here.
ROHIBITED ITEMS/WEAPONS
AEROSOLS
GENERAL WASTE
AEROSOLS
DONATED
TO CHARITY
A Brisbane Airport initiative
in partnership with GIVIT
GIVIT

People in the picture (left from right): Wendy Weir (BAC), Caet Young (GIVIT) and Tony Spencer (BAC)

Results (Environmental Benefit/Cost Benefit):

So far, more than 180 items have been donated via the new LAGS bin. Through GIVIT these items are now reaching charities and going to needy people experiencing homelessness or those living in hostels or

safe houses.

Lessons Learned:

Passengers do not source separate recyclables from waste very well, and few passengers dispose of their LAGS prior to the security screening point. As a result, this project is not making much difference to the reduction of aerosols being incinerated.

Brisbane Airport and GIVIT will commence lobbying the Australian government to allow screening contractors to ask passengers if they consent to their aerosols going to charity, rather than incineration. This will enable much greater redirection of good quality aerosols going to under privileged and needy members of the community.

ECO AIRPORT TOOLKIT

Hong Kong International Airport: Environmental Management Recognition Scheme

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interested in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Mike Kilburn
Organization/Company	Airport Authority Hong Kong
Job Title	Assistant General Manager
Email Address	mike.kilburn@hkairport.com
Telephone	2188 7713
Airport *(Name and 3 Letter Code)*	Hong Kong International Airport (HKG)

Step 2: Please provide the following basic information of your Project/~~Case Study~~:

Project/Case Study Title: HKIA Environmental Management Recognition Scheme

Timeframe (e.g., start and end month/year if applicable): 2014-2015

Description & Purpose:

Airport Authority Hong Kong (AAHK)'s Hong Kong International Airport (HKIA) Environmental Management Recognition Scheme (the Scheme) was first launched in 2012. It is conducted on a bi-annual basis, targeting key themes relevant to AAHK's environmental agenda and is designed to raise tenants' and business partners' awareness on environmental management aspects. The scheme encourages participating tenants to take direct responsibility for their environmental footprint and provides a transparent way for AAHK to measure and recognise tenants' achievements.

In 2014, the theme of the Scheme was "Waste Management". It aimed to raise tenants' awareness on waste reduction and recycling. The 6-month scheme attracted 42 tenants to participate and be accredited by AAHK's independent consultant. The participating tenants were required to meet rigorous criteria on environmental management, in particular waste management, and implement a range of environmental measures depending on the nature of their business. The Scheme was designed to rate participating outlets/shops under two sectors (F&B and retail) on their achievements within six environmental categories, of which waste management carried double weighting. Other categories included energy efficiency, water efficiency, air pollution management, noise management and overall environmental management. Waste management initiatives that received favorable scoring included a) demonstrable food waste management, b) reduced usage of disposable cutlery, and (c) programmes to encourage customers to bring their own bags.

All applicants were required to submit an Environmental Management Plan which included a waste management strategy, initiatives to be implemented and at least three waste management measures with expected outcomes. Tenants were assessed on-site both under planned and surprise conditions and were accountable for consistently meeting the requirements of the schemes in order to be accredited.

Outstanding participants were invited to give a presentation to a judging panel. AAHK selected a judging panel that included AAHK's management, green NGOs and professional associations. One winner from each sector (i.e. F&B and retail) was selected to receive the grand award. An award ceremony was organized in March 2015 to recognize the accomplishments of the tenants. HKSAR Government's Secretary for the Environment attended the ceremony.

Step 3: Please identify which waste processing is/are used at your airport:

(✓) Recycling

( ) Waste Recovery (e.g Waste to Energy)

( ) Incineration

(✓) Landfill

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(4) Economic

(1) Environmental

(5) Political

(3) Social

(2) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

An analysis of waste from terminals revealed that F&B and retail sectors contributed approximately 30% of HKIA's total waste. The 2014 Scheme was designed to predominantly focus on these two sectors as a way to address significant waste sources. Most importantly, the overall improvement in waste management by participants assists AAHK in meeting its' pledge to be the world's greenest airport and to achieve its long term waste target to reduce/recycle/recover 50% of all waste by 2021.

The HKSAR government is expected to introduce the Municipal Solid Waste (MSW) charging legislation by 2019. To enhance awareness of the implications of this legislation, the 2016 Scheme was designed to prepare the airport community for the upcoming charging scheme by driving the tenants to develop and consistently implement their own waste reduction/recycling measures in their daily operations.

The 2016 Scheme has also been enhanced to provide financial incentives to frontline staff by awarding HKIA coupons worth up to HK$6,000 to accredited participants. The participating companies were required to provide evidence that the HKIA coupons were distributed directly to front-line staff.

Step 6: Could you please describe your labeling/colour coding for waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

HKIA's labeling/colour coding of the recycling facilities (i.e. public recycling bins in terminal buildings and back-of-house recycling bins in refuse rooms) aligns with the HKSAR Government's current practice. Blue bins are for paper, yellow bins are for aluminum, and brown bins are for plastic.

To facilitate the airport tenants to separate waste at source, AAHK provides free recycling bags and bins for tenants. Transparent bags are used to collect dry recyclables such as paper, plastic, cans and glass bottles, and red bags are used to collect food waste. Tenants and business partners are encouraged to place separated recyclables into designated recycling bins during waste disposal.

The harmonization of labeling/colour codes for waste separation would be useful in the context of cabin waste recycling. AAHK collaborated with airlines, the Association of Asia Pacific Airlines (AAPA), Airports Council International (ACI) and the International Air Transport Association (IATA) to develop the "Cabin Waste Recycling Guidance and Recommendation Practices", which was published in 2016. There is a recommendation in the guideline about the harmonization of labeling/colour codes for waste separation. However, it is not a mandatory requirement across all airports. Currently, there is no global standard for labeling/colour coding of recyclables. At HKIA, different airlines/cleaning companies may have their own set of labeling/colour coding of recyclables across fleets. The development of a uniform system for labeling/colour codes with regard to waste separation would assist global aviation to minimize the risk of cross contamination and improve recycling rates.

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

The HKIA Environmental Management Recognition Scheme is a voluntary airport-wide biannual programme. In 2012, 38 tenants in the retail and F&B sectors within the terminal buildings participated. In 2014, the scheme expanded to an airport-wide programme which covered retail and F&B business partners across the airport. In 2016, the programme expanded to include the office and cleaning contractor categories, in addition to the retail and F&B sectors, and attracted 102 participants airport-wide.

As part of the Scheme, AAHK engages with the tenants regularly and provides training sessions and tools (such as recycling bags and bins) free of charge to assist business partners and tenants to achieve the best possible outcomes. Where possible, participants are invited to provide feedback via surveys to ensure enhancements can be made to facilities where necessary.

During the 2014 Scheme, ten organizations including government departments, industry bodies, and green NGOs were invited to be supporting organizations. In addition to ensuring that the judging was conducted by independent experts this approach also helped to spread awareness of the programme to the wider Hong Kong community, five of these organisations also participated in the final judging process for the selection of the Grand Award winners for the Scheme.

Since 2012, the Scheme has attracted the support of the Hong Kong Government's Secretary for the Environment, as well as AAHK's CEO and directors, participating tenants' senior management and NGOs, all of whom attended the opening and closing ceremonies of each biannual scheme. This recognition serves as a compelling driver for the successful and continuous implementation of the Scheme.

Step 8: Which department is in charge of waste management in your organization?

The Sustainability Department is responsible for formulating AAHK's waste management strategy and initiating "airport-wide" waste management programmes across HKIA. The Sustainability Department works closely with other operational departments to implement initiatives across AAHK's operations and embeds requirements within contract agreements to ensure measures are also enforced throughout the supply chain.

Step 9: Please insert Text and Images of your project~~/case study~~ below here:

Decision-Making Process:

The Scheme was endorsed by the AAHK's Executive Director. AAHK engaged a consultant to deliver the project which included developing the scoring methodology, providing independent assessments and conducting opening or closing ceremonies.

Estimated Cost and Financial mechanisms available:

The Scheme is free-of-charge for participating tenants. AAHK chooses not to disclose the project costs.

Images:

Results (Environmental Benefit/Cost Benefit):

The 2014 Scheme resulted in the accreditation of 19 food and beverage outlets and 23 retail stores (i.e. about 15% of the total tenants at HKIA) including one Grand Award winner from each category.

The Grand Award winner for the retail sector (The Magic of Hong Kong Disneyland) reduced 15% of their packaging materials (approx. 72,600 pcs of plastics bags and paper boxes for their products) in a year. The Grand Award winner for F&B (Catalina's restaurant) developed some very innovative practices including replacing hardcopy restaurant menus with electronic menus to save paper and made an agreement with its detergent supplier to reuse containers.

Riding on the success of the 2014 programme, the scheme was launched again in 2016 and expanded to 20 months and covered four sectors, including F&B, retail, office and cleaning contractor. The scheme has attracted 102 tenants. A passenger awareness programme (PAP) was newly introduced in the 2016 scheme in order to enlighten passengers and the general public on the benefits of waste management, waste reduction and recycling through a series of promotional and educational activities that made use of the Hong Kong Government's "Big Waster" mascot.

This Scheme could be readily adopted by other airports without significant capital investment.

ECO AIRPORT TOOLKIT

Sacramento County Airport System: Food Waste Diversion Pilot Program

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Tiffany Pham
Organization/Company	Sacramento County Airport System
Job Title	Environmental Specialist
Email Address	phamti@saccounty.net
Telephone	916-874-0754

Airport *(Name and 3 Letter Code)*	Sacramento International Airport (SMF)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Sacramento International Airport Food Waste Diversion Pilot Program

Timeframe (e.g., start and end month/year if applicable): January 2015 to March 2016

Description: Sacramento International Airport implemented a pilot program for pre-consumer food waste collection and diversion activities at participating restaurants as part of a larger demonstration project by Sacramento Municipal Utility District(SMUD) and CleanWorld, an anaerobic digester technology company, to develop food waste collection infrastructure across the Sacramento region.

Purpose: The purpose of the project was to test and analyze food waste diversion ahead of California's Mandatory Organics Recycling regulation (AB 1826). SMF volunteered to be a participating facility to help SMUD and CleanWorld understand any logistical issues with implementing a food waste diversion program.

Step 3: Please identify which waste processing is/are used at your airport:

(x) Recycling

(x) Waste Recovery (e.g. Waste to Energy)

( ) Incineration

(x) Landfill

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(3) Environmental

( ) Political

(4) Social-hidden driver. Benefit from employee engagement

(1) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Atlas Disposal, SMF's waste hauler, approached SMF to participate in a food waste diversion pilot project in preparation for AB1826, a mandatory commercial organics recycling mandate. The purpose of the pilot program was to test food waste collection and diversion activities. Doing so would provide guidance to other facilities that would be required to comply with AB 1826.

At the time of the pilot program, Atlas endeavored to structure food waste to be more cost effective than sending waste to the landfill and result in waste management cost reductions. Involvement in the pilot program allowed Airports to purchase waste management infrastructure (i.e.: receptacles, tilt trucks) for participating Concessionaires with the use of grant funding.

Implementing a food waste diversion pilot program would also limit the amount of waste sent to the landfill and limit Airport-sourced greenhouse gas emissions. Food waste would be sent to a high-solids anaerobic digester which captures 100 percent of the greenhouse gas emissions from organic waste to produce renewable natural gas. Renewable natural gas is then used to fuel waste hauler fleets resulting in a closed loop system.

Employee engagement and the social benefit was an unexpected by-product of the pilot program. SMF's Waste Management Working Group (WaMWG) formed around the same time SMF was invited to participate in the food waste diversion pilot program. At the conception of the working group, there was a greater motivation to produce positive results. Many employees felt a greater sense of purpose and felt they were performing meaningful work as a result of the working group.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

Concessionaires have color-coded receptacles, tilt trucks, and compactors for waste separation and disposal. Front of the house and back of the house employees dispose of waste in receptacles. Utility workers take waste from the receptacles to the tilt trucks behind the restaurant until the tilt trucks are full. Tilt trucks are taken to the compactors at least once a day, where Atlas will pick up and haul the waste to the appropriate facility.

All receptacles, tilt trucks, and compactors are color-coded to differentiate between the three waste streams. Gray indicates receptacles for trash disposal. Blue indicates receptacles for comingled recycling. Yellow indicates receptacles for food waste diversion. Yellow was chosen as the color for food waste diversion because green receptacles symbolize yard trimming disposal in Sacramento County. Because food waste and plant trimmings are accepted at separate processing facilities, green could not be used for food waste diversion.

Given SMF's current international passenger numbers, international harmonization of labeling and color codes would not make a significant impact on waste separation results. However, as SMF expects a greater number of international flights, harmonization would be beneficial for passengers who do not speak English and must rely on colors and symbols to identify the correct receptacle to dispose of their waste.

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

SMF's Waste Management Working Group, made up of individuals from various airport divisions, worked to implement the food waste diversion pilot project. SMUD partnered with CleanWorld to develop food waste collection infrastructure across the Sacramento region. SMF volunteered to be one of the test facilities. Atlas Disposal provided hauling services and transport for the food waste to CleanWorld.

Step 8: Which department is in charge of waste management in your organization?

Responsibilities for waste management are shared between the airport's landscape management division and environmental division. The landscape management division manages the waste hauler contract and maintains waste management infrastructure (i.e.: compactors, towable bins). The environmental division is responsible for providing training to the Food & Beverage Concessionaires and managing the Concessionaire Recycling Program. During the food waste recycling pilot program, a person from the landscape management and environmental division performed daily waste assessments of the Concessionaires participating in the pilot program.

Step 9: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

SMF's Waste Management Working Group was approached by Atlas to participate in a food waste pilot program headed by SMUD and CleanWorld. Knowing that AB 1826, a mandatory commercial organics recycling regulation, would begin enforcement in April 2016, SMF presented Atlas' offer to Airport Management. Participation in the food waste diversion pilot program was endorsed with the agreement that participation would not result in any additional costs to the airport.

Estimated Cost and Financial mechanisms available:

SMUD was awarded $100,000 in grant funding by the California Energy Commission to promote growth of biomass-to-energy technology. Approximately $20,000 of the grant funding was spent on color-coded receptacles, tilt carts, and recycling incentives for the six participating restaurants at SMF. In order to realize a cost-savings outcome, there were no other financial mechanisms to permit implementation of the food waste diversion program.

Images:

Figure 1: Pilot Project Process Flow

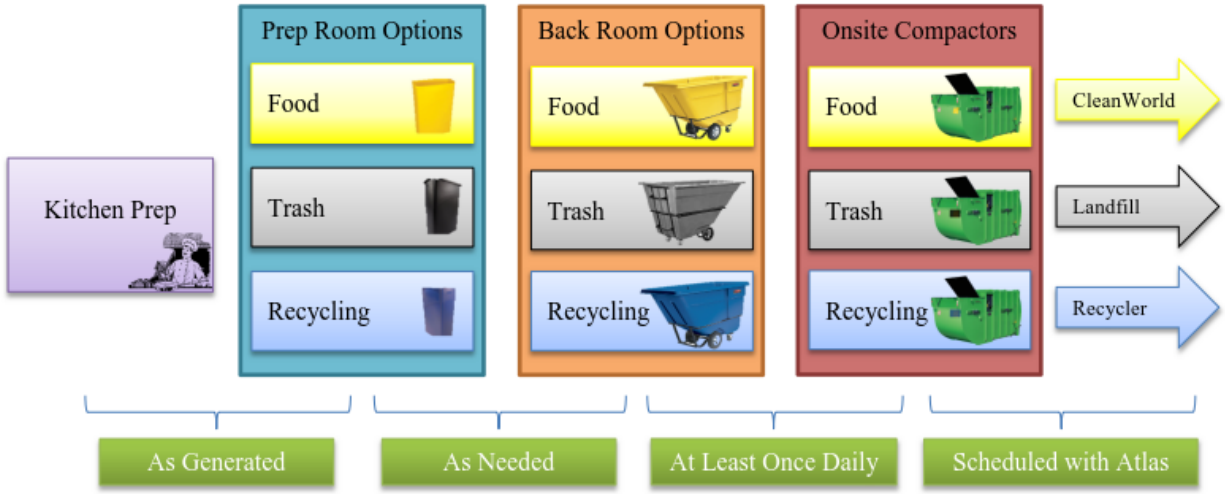
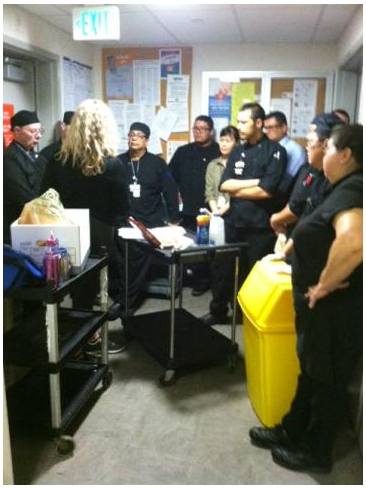


Figure 2: Food Waste and Recycling Receptacles

Figure 3: Food Waste, Trash, and Recycling Tilt Trucks

Figure 5: Food Waste, Trash, and Recycling Compactors

Figure 6: Concessionaire Recycling Training



Results (Environmental Benefit/Cost Benefit):

Nine tons of food waste was diverted to CleanWorld's anaerobic digester that would have otherwise gone to the landfill during the initial six-week phase of the pilot program. The landscape management division worked closely with Atlas Disposal to decide on frequency of hauling food waste. Factors that contributed to the decision included: how much tonnage capacity the compactor could take, cost of hauling, and minimizing pest-conducive conditions due to odor and ambient temperature. The cost per ton of disposal for trash was 35 cents higher than the cost per ton of disposal for food waste, which resulted in a minor cost savings.

Lessons Learned:

Increased Recycling: The Waste Management Working Group (WaMWG) not only trained Concessionaire employees about food waste diversion, but also comingled recyclable diversion. Many of the Concessionaire employees learned about recycling concepts for the first time during the food waste diversion pilot program. As a result of the training, there was a significant increase in recycling and a decrease in trash.

Space is Critical: Many Concessionaire spaces were designed without consideration for multi-bin placement. WaMWG noticed employees were disposing of their waste in the bin closest to their station despite recycling training and enforcement. Convenience and accessibility are important drivers for getting Concessionaire employees to recycle properly. To address the issue, WaMWG worked with supervisors and managers to strategically place certain receptacles where waste is created.

Continuous training and monitoring: The amount of training required for restaurants was underestimated due to the number of part-time employees and extremely high turnover in the food industry. It was initially expected that only a handful of trainings per restaurant were required and any new employees could be trained by seasoned employees. Instead, WaMWG had to give recurring recycling trainings as some restaurants hired new employees on a bi-weekly or monthly basis.

Recurring monitoring is required for all hours of operation. If recycling monitors had the tendency to visit one work shift more than others, the highly monitored shift would have greater compliance than the less visited work shift. Therefore, WaMWG alternated the time at which to monitor recycling practices of Concessionaires.

Odor Mitigation: During the pilot program, SMF staff received one complaint about odor around the compactor. Investigation identified the following lessons:

- Liquid may spill during the emptying of tilt trucks into the compactor and this spilled liquid is a source of odor if not properly cleaned
- The smell was not coming from the food compactor itself but from food that did not make it into the compactor

Food handling is an important aspect of odor management. Some of the concessionaires were not bagging food waste which contributed to odor in the bins and spillage in the compactor area. Continued training was provided to educate staff and managers about the use of the bags and that they are acceptable in the food waste bin (some staff thought the food waste had to be 100 percent clean).

SMF explored additional alternatives to manage odors near the compactors. Ozone generators were not compatible with SMF's waste infrastructure as they are known to deteriorate metal compactors. Instead SMF installed an odor neutralizing misting system above the food waste compactor.

ECO AIRPORT TOOLKIT

San Diego Regional Airport Authority: SAN's Food Recovery Program

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Mayra I. Garcia
Organization/Company	San Diego County Regional Airport Authority
Job Title	Associate Environmental Specialist
Email Address	MiGarcia@san.org
Telephone	619-400-2795
Airport *(Name and 3 Letter Code)*	SAN

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: SAN's Food Recovery Program

Timeframe (e.g., start and end month/year if applicable): 2014 ongoing.

Description: The San Diego International Airport serves as the gateway in and out of San Diego, providing service to over 22 million travelers in 2017. Given the volume of hungry travelers filtering into and out of the airport, there is a lot of food being purchased and consumed, which leads to opportunities for food recovery. As an alternative to food waste taking up valuable space in local landfills, in 2013, the San Diego County Regional Airport Authority (Authority) began collaboration with one food service provider to collect coffee grounds and fruits for composting through the City of San Diego's Miramar Greenery Composting Facility. In 2014, the Airport's program expanded to include 40 restaurants and coffee shops at the airport that were collecting and composting all their pre-consumer food scraps, not just coffee grounds and vegetative food waste. This marked the beginning of the Airport's Food Recovery Program – a collaboration with airport concessionaires, Flagship Airport Services (the airport's sole janitorial service provider), Bradford Airport Logistics (the airport's receiving and distribution service provider operating a fleet of refrigerated vehicles), Republic Services (the airport's sole waste hauler), and the City of San Diego. By the end of 2015, three prep kitchens, the Airport's United Service Organizations (USO) Neil Ash Airport Center, and three of the Authority's own breakrooms were participating in the program, sending 320 tons of pre-consumer food waste to the City of San Diego Miramar Greenery. New for 2016, the Food Recovery Program began a pilot project to collect the scraps of food left on plates (post-consumer food waste) in all seven wait-service restaurants at the Airport. The pilot included oversight by the Authority and the City of San Diego Environmental Services Department, and training of restaurant managers and staff on the mechanics of the food recovery program. The pilot program was a resounding success and the City approved formal implementation of post-consumer food waste collection as part of the Airport Authority's Food Recovery Program. By separating food waste from the waste stream, the Airport has reduced the volume of waste disposed as trash. In 2017, the Airport Authority diverted 368 tons of non-edible food waste to the City of San Diego Miramar Greenery for composting. At the Miramar Greenery, compost is made from yard trimmings and food scraps that have been ground, placed in windrows, turned and watered for 70 days. During this time, microorganisms digest the carbon and nitrogen rich mixture, causing the windrow to sustain temperatures of 140-165 F. This process eliminates most weed seeds and pathogens while breaking down the organic material into beneficial soil nutrients. Finished compost is screened to a particle size of one-half inch or less which also removes film plastic from the final product. Compost is used as an amendment to improve soil texture and increase nutrient and water holding capacity. In San Diego, where soil lacks many essential plant nutrients, mixing compost with the soil is good for yard and gardens. City of San Diego residents can self-load up to two cubic yards of compost or mulch for free with proof of residency.

Having made great strides in diverting food waste away from disposal and into composting, the Authority sought to minimize edible food waste at the Airport all together. In late 2016, the Airport's Food Recovery Program sought to reduce the amount of food waste being generated by initiating a program to donate edible food items before they need to be managed as waste. A team of Authority staff worked

with the Airport's six main concessionaires, Flagship Services, Bradford Airport Logistics, the San Diego Rescue Mission and other non-profits, including Feeding America, to donate food as meals to local communities (saving the community approximately $100,000 by providing nearly 5,000 meals). In the process, the team realized there was a need to be filled that was even closer to home, right at the airport itself – the USO Neil Ash Airport Center. The USO Neil Ash Airport Center is open to active duty service members and their families and is the largest of its kind in the world, with an estimate of 11,000 visitors per month. The USO provides a resting space, entertainment, and meals for these visitors and their families. The Airport Authority's Food Recovery Program has created a closed-loop system that enables restaurants and concessionaires at the Airport to direct edible excess food to another worthy cause right here at home. The USO now has the distinction of both receiving on-site food donations and participating in our food waste collection program. The Authority has become an example to other airports and businesses that are looking to start their own Food Diversion Programs, and the team has been contacted by numerous outside organizations for information. The Airport's Food Recovery Program represents 28% of the non-construction-related waste diverted from landfill disposal by the Airport Authority in 2017. The Airport continues to collaborate with the San Diego Food System Alliance to develop and maintain a sustainable food system in San Diego County.

Purpose:

In 2013, when the Authority joined the City of San Diego's Composting Program the Authority had to comply with the City's program guidelines and requirements. One of the requirements that had to be met was to have three clean loads delivered to the Miramar Greenery. At the greenery the loads were inspected by the City of SD staff, also in attendance was the Authority and Flagship Services staff. The three loads had to be clean and could not exceed 1% contamination. In order to meet this requirement, Authority developed training materials and provided employee training including Flagship staff and concessionaires. During the inspections the Authority learned that there were large quantities of edible food being thrown away and that could be saved. The Authority started the food recovery program in an effort to divert the edible food and feed hungry people in the community. One year later, the Authority joined the EPA Food Recovery Challenge in 2015. During the same year, the White House, EPA and the U.S. Department of Agriculture announced a national goal to cut food waste in half by 2030. As part of the effort, the federal government will lead a new partnership with non-profit organizations, the private sector and local, state and tribal governments to reduce food loss and waste in order to improve food security, while conserving our nation's natural resources. After recycling and composting, food waste was the largest component of MSW discards at 21.1 percent, more than plastic or paper in 2013. According to the EPA we continue to discard more food waste to landfill compared to all of our other municipal solid waste. And yet, food waste is the least recovered material. The good news is that food recovery rates have more than doubled from 2009 to 2013.

Step 3: Please identify which waste processing is/are used at your airport:

(x) Recycling

The Authority operates a centralized waste and recycling facility which houses a covered area for the cardboard and baler, open area containing one solar-hybrid powered trash and recycling compactors, one tipper trash compactor, one custom food waste compactor, one dumpster for wood and pallets, one

container for metals, and twenty-five towable carts for use with the tipper compactors. Bradford operates a baler for plastic film that is recovered during deliveries from the concessionaires.

(x) Waste Recovery (e.g Waste to Energy)

Grease is collected from the concessions and it is turn into bio-fuel, Bradford uses the grease in their delivery trucks on campus.

( ) Incineration

(x) Landfill

Trash is taken to the Miramar landfill.

(x) Other – Diverting edible food from the landfill and donating to non-profit organizations (USO and the SD Rescue Mission).

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(5) Political

(3) Social

(4) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

- 40% of the food produced in the US is wasted.
- 1 in 6 Americans is food insecure.
- Decrease GHG emissions methane produced in landfills.
- Authority has reduced landfill hauling fees.
- Increase SAN's overall MSW diversion rate.
- Incentives for the food and beverage concessions they receive tax deduction for the food donations.
- The Authority educates concessionaires to follow the EPA's Food Recovery Hierarchy and to prioritize their actions to prevent and divert wasted food. Each tier of the Food Recovery Hierarchy focuses on different management strategies for your wasted food.
- Recognition from the EPA in 2017 was awarded to SAN in the innovation category.
- Recognition from the San Diego Food System Alliance in 2016 SAN was recognize with an EMIES Unwasted Food Award.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

The Authority provides the reusable blue color totes, shown below and are labeled FOOD DONATIONS, SDCRAA, USO these are exclusive for Bradford to pick up during their scheduled deliveries and taken to the USO.

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

Stakeholders included the airport concessionaires, Flagship Airport Services (the airport's sole janitorial service provider), Bradford Airport Logistics (the airport's receiving and distribution service provider operating a fleet of refrigerated vehicles), Republic Services (the airport's sole waste hauler), USO, and the City of San Diego.

Step 8: Which department is in charge of waste management in your organization?

The Authority's Planning & Environmental Affairs Department and Terminals & Tenants Department oversee waste management contract and monitor the status of related activities.

Decision-Making Process: Management support has been key and collaboration with all the steakholders.

Estimated Cost and Financial mechanisms available:

During 2017, the Authority saved $18,170. Landfill fees are $46 per ton; 368 tons of food scrap was delivered from the landfill saving $16,928 and $1,242 for diverting 27 tons of edible food donations.

Step 9: Please insert Text and Images of your project/case study below here:

Results (Environmental Benefit/Cost Benefit): During 2017, the Authority saved $18,170. Landfill fees are $46 per ton; 368 tons of food scrap was delivered from the landfill saving $16,928 and $1,242 for diverting 27 tons of edible food donations.

Lessons Learned:

The Authority continues to improve the processes and communication with all the stakeholders involved are key. The Authority started a Green Concessions program in 2017, and concessions meet with Environmental staff to find out what type of sustainability practices they currently have in place and what they can improve on. During this time staff can recommend participation in food donations program. The Authority is constantly updating the program guidelines, developing compliance guidelines, and employee training.

On-going education through monthly presentations we present on waste reduction to the concessionaires and, provide resources on the Good Samaritan Act to provide ease of donations of edible food with expired dates. We learned that there's still uncertainty on items that can be donated and the liability that the business could potentially face. The Federal Bill Emerson Good Samaritan Food Donation Act protects the donor and the recipient agency against liability. In addition, each state has passed Good Samaritan Laws that provide liability protection to good faith donors.

ECO AIRPORT TOOLKIT

San Francisco International Airport: Achieving Zero Waste by 2021: Maximizing Materials Management at SFO

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Jennifer Acton
Organization/Company	San Francisco International Airport (SFO)
Job Title	Environmental Operations Manager
Email Address	Jennifer.acton@flysfo.com
Telephone	650-821-8380
Airport *(Name and 3 Letter Code)*	San Francisco International Airport (SFO)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Achieving Zero Waste by 2021: Maximizing Materials Management at the San Francisco International Airport (SFO)

Timeframe (e.g., start and end month/year if applicable): Ongoing; Zero Waste goals outlined in SFO's 2016-2021 Strategic Plan, adopted and initiated in June 2016.

Description: To get to Zero, the Airport has co-designed and will soon release its first Zero Waste Plan, which contains the suite of measures required to achieve 90% diversion by 2021. In the years that follow, the Airport will work towards becoming a Closed-Loop Circular Campus. This will require the Airport's dynamic group of materials managers, located across our organization, to track new metrics, test new technologies, try new behavior-focused campaigns, and team with new stakeholders to transform our current landfill-focused system. In this way, the Airport's First Zero Waste Plan strives not just to engage, but also to enable SFO to bring positive change to some of the largest challenges of our current time – climate change, human health risks, ecosystem destruction, and beyond.

Purpose: The City of San Francisco and the San Francisco Airport Commission have a long history of and continued commitment toward environmental leadership, natural resource stewardship and climate action. Reflecting this commitment, the San Francisco International Airport (SFO or the Airport) has established the bold, Strategic Plan goal of becoming the world's first zero waste Airport by 2021. In setting this target, our Airport asks the question of "how low can we go?" within our 14 million square foot campus materials system. The first Airport Zero Waste Plan presents SFO's pathway to respond to this question and achieve our "zero" goal from a baseline of 12,200 short tons of materials generated on our campus last fiscal year.

Step 3: Please identify which waste processing is/are used at your airport:

(x) Recycling

(x) Waste Recovery (e.g Waste to Energy)

( ) Incineration

(x) Landfill

(x) Other _Compost_____

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(1) Environmental

(4) Political

(5) Social

(2) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

As described in our program purpose, SFO is first and foremost committed to environmental leadership, natural resource stewardship, and climate action. In 2016, this encouraged our Airport to establish a bold Strategic Plan of "Achieve Zero", which includes our campus wide goal of reaching Zero Waste by 2021.

But all good goals are grounded in meeting compliance obligations first. The State of California and the City and County of San Francisco have established landfill diversion requirements through legislation. At the state level, the California Integrated Waste Management Act of 1989 mandated that each city/county/regional agency must develop a waste management plan that would produce a 50% diversion rate of all solid waste from landfill. The subsequent passage of AB 341 in 2011 set the ambitious policy goal for California that not less than 75 percent of solid waste generated be source reduced, recycled, or composted by the year 2020. At the local level, as a department of the City and County of San Francisco, SFO must comply with the Environment Code, which mandates composting and recycling by all people in San Francisco (businesses and residents alike) and requires that all Food Service Ware across the city be either recyclable or compostable. In 2003, the City also adopted a goal of Zero Waste by 2020. These mandates launched SFO's early-stage materials management efforts and provided Airport staff the opportunity to develop and implement innovative source reduction, onsite reuse, and offsite recycling services, among other programs.

The Airport's waste collection contract lists handling costs in terms of dollars per ton for each material stream. Though cost savings from more effective materials management is not our main driver, SFO receives a collection fee discount from the waste hauler for recyclable materials, specifically metals and cardboard.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation?

Like most Airports, SFO has done its due diligence to determine the most intuitive signage for its key end users – passengers. We continue to update this based upon the often changing materiality of the concession ecosystem. Labeling and color-coding are consistent with sorting rules determined by our waste hauler. The color-coding also matches those colors used in the City and County of San Francisco. Resources are attached that illustrate this simplified system, but for ease, the colors are coded as follows: green=compost, blue=recycling, black=landfill. Recently, SFO initiated a comprehensive project to upgrade, standardize, and improve the terminal public-facing materials bins. To inform this project, a study of passenger behavior was first conducted based upon several redesign templates of bin signage, including incorporation of new iconography relating to items most often purchased by passengers at the airport. When previewing this with passenger focus groups, the airport team identified the following keys

to sorting success: straightforward phrasing, clear and simple icons, standardized color coordination, and consistently accessible placement of trios throughout the terminals.

SFO is actively working to deploy this new signage across newly designed trios as all new capital projects come online. Deploying the full-scale implementation of these new bins is cost-constrained, so to keep the Airport on track to meeting it's zero target, SFO's Facilities Operations worked to develop an interim solution. All existing bins are now being retrofit with new lids and labels that introduce the new Airport-wide standard for materials sorting and signage. This current roll-out enables SFO's passengers to improve source separation of materials into compostable, recycling, and landfilled categories at present time rather than waiting until each capital project is delivered. Current "refreshed" bins will be reused and rotated across the campus to non-terminal facilities, including parking garages.

Another key element of designing and delivering a successful program at SFO is expanding this messaging throughout all facilities and points of collection and delivery, not just passenger-facing terminals. Specifically, central solid waste collection areas have been "rebranded" as Materials Recovery Areas (MRAs). In these areas, compactors and roll-off bins feature the same new messaging with the combination of iconography, color, and wording that is used on the public-facing bins to provide consistency of messaging throughout the materials recovery stream. This, along with numerous training events, has helped coach the Airport's materials managers, whether concession or custodial staff, to properly retain source-separated materials when placing them in the proper compactor or bin.

Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

SFO would benefit from international harmonization of labeling/color codes. We are a major international gateway to the world for 55.8 Million people, and serve nearly x# of international passengers each year. We work to build amenities and services that enable an exceptional passenger experience, and consider our materials management a key aspect of this work. As we evolve our outreach and messaging to passengers, it would be beneficial to leverage internationally recognized waste disposal signage and color-coding introduced and reinforced at Airports worldwide, especially with the presence of many languages. The more we partner, the higher the likelihood we'll be able to encourage the right behaviors that allow us to reach our airport, local, and global environmental goals of minimizing materials sent to landfill.

Step 7: Did you engage with internal and external stakeholders (to do what?)? If so, please identify which stakeholders you engaged with.

SFO uses an Integrated Project Delivery Model for all of its Capital Projects, and this serves as the template for the Airport to partner on all projects whether large or small. When setting its Strategic Plan goals, the Airport convened a forum of environmental experts to establish a next generation suite of performance-based "Big Hairy Audacious Goals" (BHAGS) that push us towards achieving bigger, bolder outcomes for our campus. These were institutionalized in our Strategic Plan, including an Objective under Goal Zero, of reaching Zero Waste by 2021.

Tasked with reaching ZERO the Airport worked to roadmap its path to achieving zero net energy, zero waste, and carbon neutrality via its first crowd-sourced Sustainability Plan drafted by nearly 100 Airport staff across every Division. One goal of this Plan was for the Airport to create a compendium Zero Waste

Plan that was created by key Airport implementers including Sustainability & Environmental Policy, Engineering, Facilities Operations, and Custodial Staff. This Plan identified the key measures the Airport needs to deliver in order to meet its, and the City's more global, zero waste goals.

In seeking to implement the Plan, SFO's custodial services, provided by Facilities Section personnel, are encouraged to make recommendations for improvements based on their hands-on experience, direct knowledge and challenges. SFO hosted focus group sessions with the custodial team, along with members of the Safety, Health and Wellness Unit, to provide a space for two-way communication regarding materials management and to identify opportunities for improving this system and worker experience. SFO has also coordinated program improvements with the waste hauler, based upon the feedback from the custodial team, as well as tenants. This practice has resulted in a strengthened sense of ownership from the custodial staff, who are acknowledged as the "zero waste heroes" in the SFO's Zero Waste Plan.

SFO also actively engages with its tenants on materials management issues: the Airport requires source separation of materials by concessionaires, airlines, and other tenants. SFO's Rules and Regulations state that tenants "shall maximize recycling and composting by providing separate, marked containers for recyclables, compostables, and landfilled waste". To motivate and support tenant participation in the Airport's materials management efforts, SFO launched a Green Business Program. The program is based on the State of California's Green Business Program, administered locally by the City and County of San Francisco and San Mateo County. The Green Business Program provides tenants with the necessary tools, training, and resources to increase back-of-house compostable and recyclable materials source separation, among other operational sustainability measures. To aide tenants even more, SFO has also developed maps of the Materials Recovery Areas; a "What Goes Where" guide, which describes items acceptable for recycling, composting, and landfilling; and Material Recovery Guides containing contact information and resources for what, where, and how to recycle and reuse items and properly handle and dispose of others (e.g. universal, electronic, hazardous waste) (images included). As an added incentive, the businesses that achieve Green Business certification are able to receive a trash disposal permit fee discount of up to $2,500 per year.

Step 8: Which department is in charge of waste management in your organization?

SFO takes an interdepartmental approach to achieving strategic plan sustainability-focused goals, including advancing progress toward zero waste. Rather than dictating programs from a singular environmental department, sustainability policies, plans, and programs are owned by unique but unified divisions across SFO, based upon their scope of service delivery (i.e. Planning, Design and Construction, and Facilities Operations). SFO's Sustainability and Environmental Policy Section leads work defined by SFO's Strategic Plan, Sustainability Plan and Climate Action Plan by teaming up with staff from multiple sections to implement these Plans' defined measures, which includes material recovery, recycling, and composting. For example, contracting for materials hauling is managed by Planning, Design, and Construction; and Facilities Operations oversees the SFO's Materials Recovery Areas (MRAs), where all materials are collected by the hauler. This contract includes handling all the materials generated at SFO, including recyclables and compostables.

Step 9: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

SFO has developed an Airport Zero Waste Plan as a roadmap for decision-making associated with projects, policies, and practices that may impact materials management, whether directly or indirectly. This Plan furthers the underlying policies and requirements of the Environment Code and FAA guidance on the topic. It includes all waste materials and their lifecycles; it also prioritizes circular, regenerative, and reuse strategies.

Estimated Cost and Financial mechanisms available:

SFO spends, on average, $160,000 a month for the hauling, disposal/recycling/composting of solid waste.

Cost constraints: As mentioned above, deploying the full-scale implementation of the new bins in the terminals is constrained by cost, which will be borne by each capital project as it comes online. The estimated cost to deploy the new trios on campus is $2.35M. The interim solution of "refreshing" bins with new lids and signage was $60,000. Note that this cost does not include the materials to produce or install signage which was done by the Airport's in-house Sign Shop.

Financial and Data-Tracking Mechanisms: Materials management activities are currently managed and budgeted by the Facilities department, which is also responsible for custodial staff and maintenance activities. The Sustainability and Environmental Policy team delivers the Green Business Program, and the Planning, Design and Construction department is responsible for the redesign of the sorting bins and management of the materials hauling contract. The material hauling contract lists handling costs in terms of dollars per ton for each material stream. SFO receives a collection fee discount for recyclable materials, specifically metals and cardboard. The Facilities department monitors the status of waste management activities, including the procurement of equipment.

The Sustainability and Environmental Policy Section measures and tracks the program's metrics including materials procured, diverted, landfilled, and associated greenhouse gas emissions. The waste collection contractor provides monthly data reports detailing the quantities of various waste materials generated at SFO; at one time, these reports were provided quarterly. To better understand the facility's waste streams and identify opportunities for improvement, SFO has completed waste characterization studies, passenger studies, and facility audits; an Airport Zero Waste Plan, recycling and waste management status reports, sustainability reports, and a Sustainability Strategy have also been developed for the facility.

Images: (Included as attachments)

Green Business Flyer – attach as separated document

Materials Recovery Tenant Guide

MRA pictures (1.signage and 2.compactor coloring)

Waste Station signage (1. New bins 2. Old bins relabeled with new lids)

Graphic Messaging image

"What goes Where?"

Material Recovery Area Map

Results (Environmental Benefit/Cost Benefit):

Ongoing: Results and Data Collection are continuous

- Standardized messaging throughout SFO terminals.
- SFO Waste Disposal Metrics:
    - FY 2016: SFO recycled and composted approximately 57% of all solid waste handled by the Airport - 6,960 tons were sent out for composting and recycling and 5,407 tons of material were sent to landfill. This diversion yielded an estimated GHG emission mitigation of 7,328 tons of CO2, whereas 1,855 CO2 tons were produced through landfilling - a net of 5,473 tons of CO2 of GHG emission mitigation (2016 Climate Action Plan).
    - FY 2017: SFO recycled or composted about 53% of all solid waste – this resulted in a net GHG emission mitigation of 6,448 tons of CO2 (increase from FY 2016), due to a significant increase in the amount of material recycled.
- Green Business Program Metrics:
    - 26 Green Businesses have been certified to date, while engaging over 100 businesses.
    - 60 metric tons of recyclable/compostable materials have been diverted as a result of the program.
    - 120 employees have been trained on appropriate waste practices.

- Cost Savings - Direct cost savings to the Airport are generated through reduced waste hauling fees for recycled materials which in the case of metals and glass generate a positive income for the Airport. Indirect cost savings are, also, realized by downstream users of the recycled and composted materials. In 2017, SFO source-separated about 2,800 tons of recyclables that included Old Corrugated Cardboards, Aluminums, Glass, Plastics, Mixed Paper and Wood. Sending these materials to landfill would have cost SFO $428,400.

Lessons Learned (and Challenges Faced):

- Importance of engaging broad stakeholder network to get results – collaborative approach with Airport Commission (Environmental Operations, Sustainability & Environmental Policy, Custodial Teams), Tenants (Airlines & Concessions), Waste Hauler
    - Continuity of training and engagement with employees (noting frequent turnover of staff and/or pivoting responsibilities) – requires ongoing, consistent, and timelined outreach and education programs.
    - Custodial collaboration, feedback, training and recommendations is a fundamental element for diversion success.
    - Know what's needed – identifying where there are gaps in the materials management chain (i.e. collection bins, front end loaders, compactors) and programing resources to ensure all stakeholders are empowered with simple solutions to support diversion (i.e. toters/carts, quarterly trainings).
    - Materials management can be an effective gateway to engaging on broader sustainability topics with tenants. Finding an easy starting point (composting/recycling) to discussing other leasehold improvements (i.e. energy and water upgrades, employee commute) is invaluable.
- The power of EP3 (Environmental Preferable Procurement Policies)
    - Developing and deploying a template policy so folks know where to start.
    - Providing support tools to ensure sure "just in time" delivery and no excess purchases.
    - Adapting to and dealing with an ever-evolving waste stream – and shaping and simplifying procurement to ensure end of life issues are navigable (addressing waste at the source).

- Making sure all stakeholders are informed of procurement requirements, embed within their own purchasing processes, and are empowered to make a change, by being given lists of alternatives.

- Simplifying messaging and graphics to fully engage and make aware an incredibly diverse and international passenger base: being sophisticated in identifying barriers to participating in materials streams, doing "proof of concept" pilots and focus groups before fully implementing a campaign, working with haulers to understand the sphere of materials handled and "what goes where" at end of life based upon their capabilities and your contract.
- $ Talks – the Airport offers tenants participating in the Green Business Program a discount on their trash permit fee, under the premise that all certified businesses are required to have recycling and composting practices and equipment within their leased space, and so save the Airport money in hauling fees (calculated savings through Airport cost recovery model).

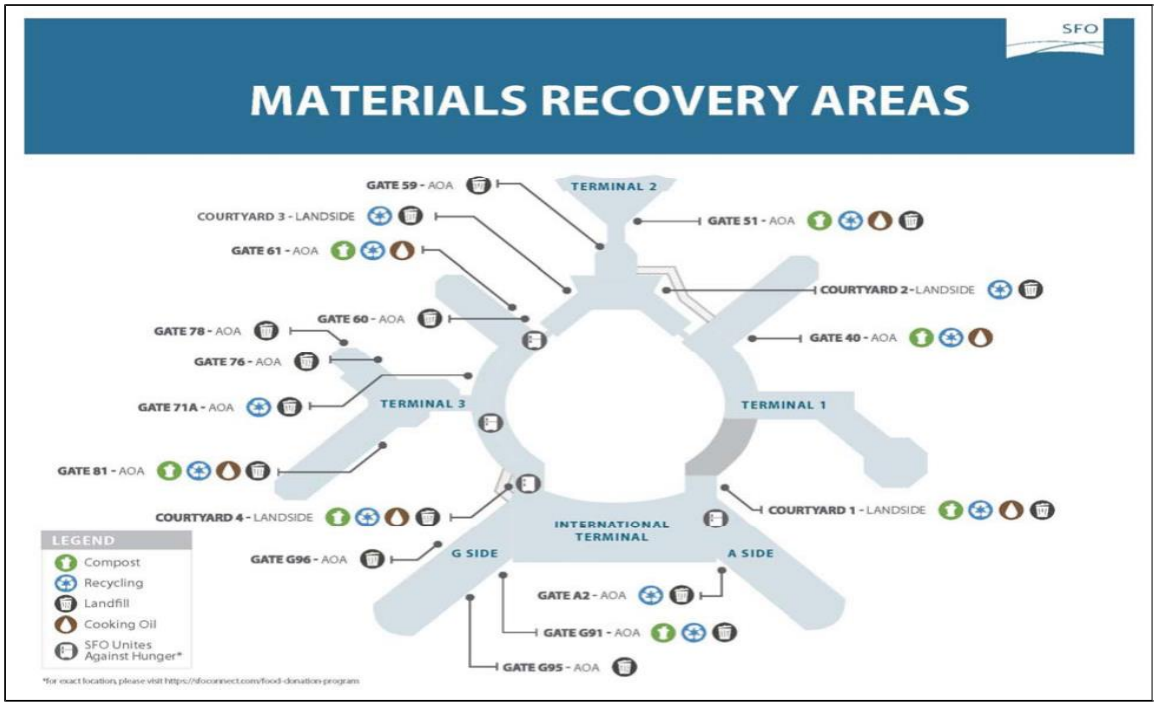


Figure 4Map of Materials Recovery Areas throughout the SFO terminal area

Figure 2: “What Goes Where” guide

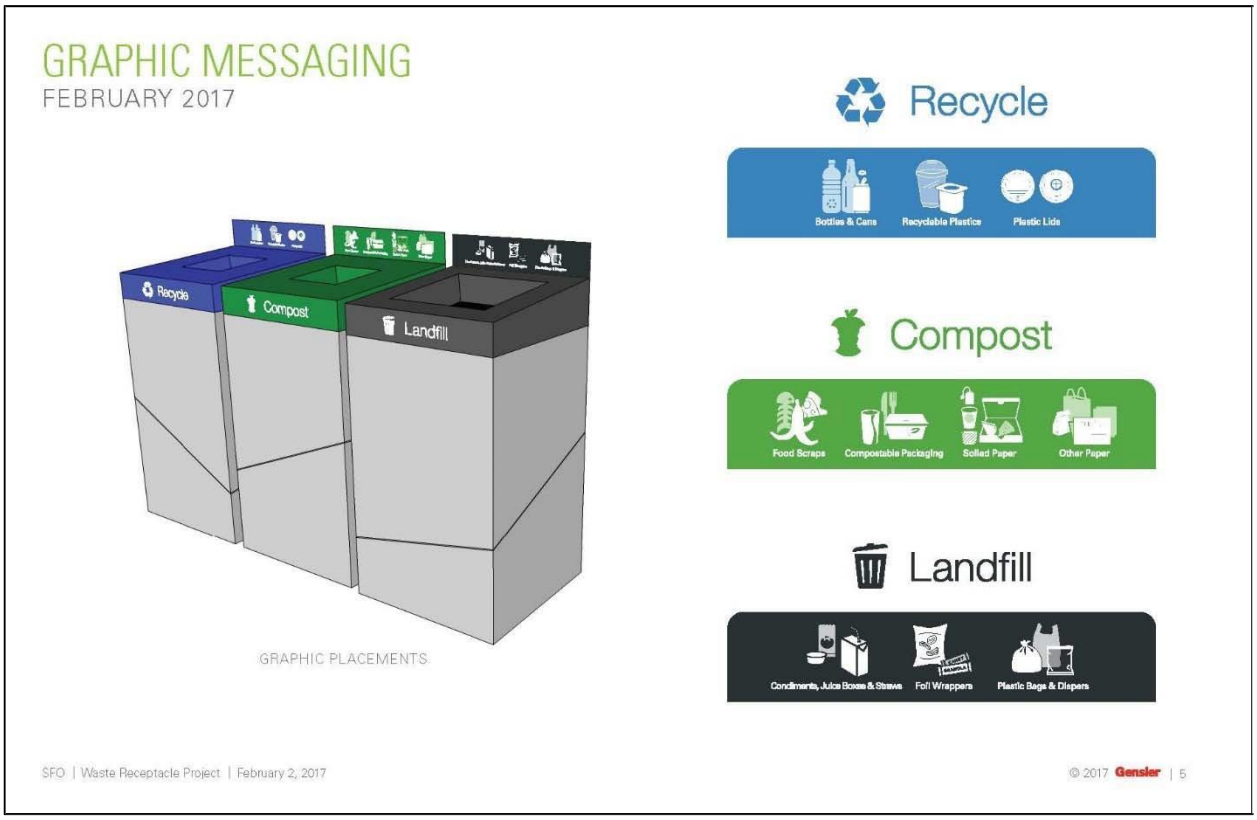


Figure 4: Standard signage integrated on new Materials Sorting Bins

Figure 5: Standard signage integrated on existing “refreshed” bins

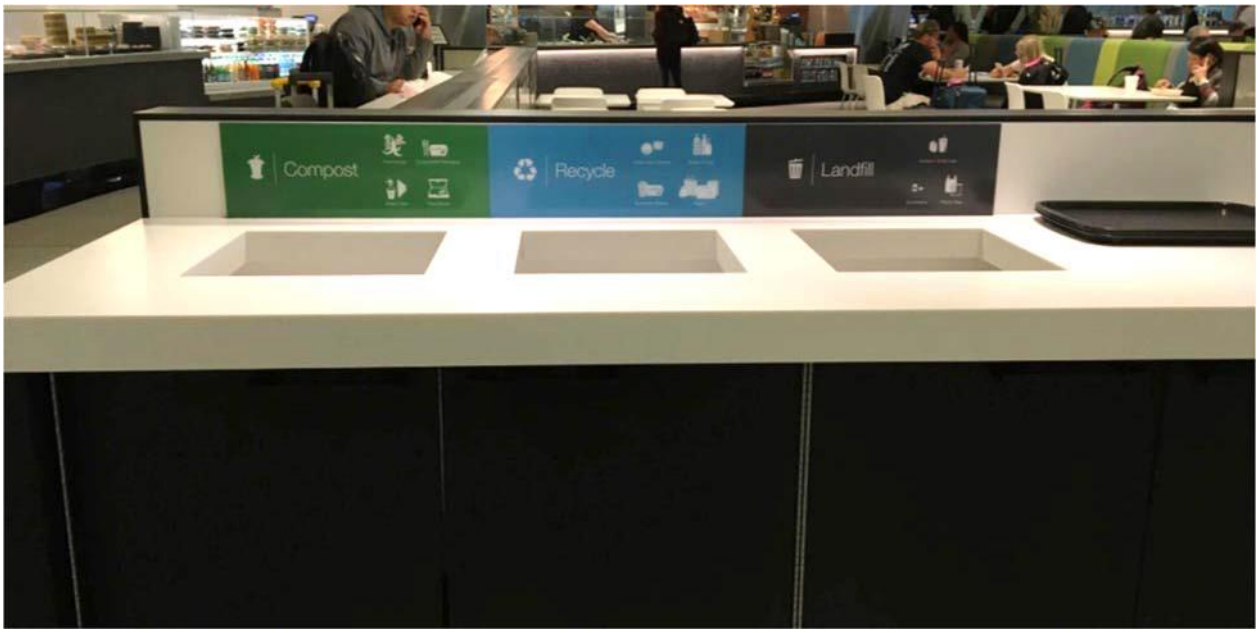


Figure 6: Standard signage on built-in Materials Sorting Bin Stations within food pier areas

Figure 7: Standard signage in Materials Recovery Area

Figure 8: Standard signage on Materials Recovery Area compactors

MATERIALS RECOVERY
TENANT GUIDE

Have an item and not sure how to reuse, reclaim, recycle or dispose of it? Read on, visit www.recyclestuff.org or www.earth911.com or email: greenbusiness@flysfo.com

Material Type	Airport Service Provider	Contact Information	Additional Resource
Compost, Recycling, Landfill Materials		Jennifer Acton x1-8380 Airport Duty Managers x1-5222 Revenue Development x1-4500	Materials Recovery Areas Map https://sfoconnect.com/sfo-green-business-program
Edible Food – DONATE IT!	**Unite Against Hunger**	SFOConcessions@flysfo.com	greenbusiness@flysfo.com
Electronic Waste Recycling		For a list of service providers visit the following resource websites:	www.recyclestuff.org www.earth911.com
Universal Waste Recycling *(batteries, pesticides, mercury-containing equipment)*	**San Mateo County Health**	www.smchealth.org/environ/toxic	www.recyclestuff.org www.earth911.com www.recyclewhere.org
Hazardous Waste *(motor oil, chemical waste, paint)*	**San Mateo County Health**	www.smchealth.org/environ/toxic For a list of SMC haulers visit link below: www.smchealth.org/sites/main/files/file-attachments/hazwaste_hauler_list.pdf	Very Small Quantity Generator (VSQG) Program: (650) 655-6217 www.smchealth.orgx/vsqg
Liquid Waste *(fats, oils, grease)*	**Darling International**	Revenue Development x1-4500 Airport Duty Managers x1-5222	
Surplus Items *(furniture, electronics, office supplies)*		*Tenants are responsible for disposing of their own **milk crates** and **pallets**	www.recyclestuff.org www.recyclewhere.org
Construction & Demolition Materials		Requirements for project Construction & Demolition Waste Please contact: Jennifer.Acton@flysfo.com	
Integrated Pest Management		Deana Noonan x1-5533	https://sfenvironment.org/download/2017-reduced-risk-pesticide-list

Interested in applying these resource recovery actions @ home? Visit to learn where household items go: www.recyclestuff.org *(scroll to bottom of the page)* or **www.recyclewhere.org**. For household toxic waste collection (batteries, light bulbs, paint, motor oil, etc.) visit: **www.flowstobay.org/toxic**

DISCLAIMER -This partial list serves as a reference only. The mention of a company does not constitute an endorsement by the Airport. For more resources visit websites listed above or www.smchealth.org/environ/toxic.

ECO AIRPORT TOOLKIT

Munich Airport: Process for the disposal of solid waste (in terminals) included analysis of mixed recyclables

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Martin Heiss
Organization/Company	Flughafen München GmbH
Job Title	Environmental Protection Officer
Email Address	Martin.heiss@munich-airport.de
Telephone	+49 89 975-51 710
Airport *(Name and 3 Letter Code)*	Munich Airport, MUC

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Process for the disposal of solid waste (in terminals) included analysis of mixed recyclables

Timeframe (e.g., start and end month/year if applicable): (Analysis: June July 2015)

Description:

Procedure

The objective of the procedure is to ensure that any solid waste from the **Terminals** is being disposed correctly and furthermore to provide the most economic waste disposal offer to the clients.

The following points listed below are the most important ones - for example:

- Meet all rules and regulations by (local) authorities
- Ensure that all waste is separated according to pre-defined categories
- Have a documented disposal-chain, so that it is ensured that the waste is handled correctly (recycled)
- Guarantee that disposal is billed according to the customers points
- Requirements for this process: IT-systems/equipment; PC operated weigher unit in the central waste rooms

All waste is being collected in different containers (waste press) at central collection points. It is important that the waste has already been separated before it is brought there. A Container takes the waste of more than one client. In the next step the waste has to be weighted and the weight and type of waste has to be documented. This is crucial in order to make sure that disposal is billed according to the causative principle.

Waste volume 2016:

- In 2016, altogether 11.321 Mg (=tons) waste (treated only by the FMG waste management department) were disposed of.
- Proportion of collection area Terminal 1: 1.493 Mg (=tons)
- Proportion of collection area Terminal 2(*): 2.421 Mg (=tons)

(*) Opening of satellite building in April 2016

Types of waste (Terminals)

Solid Waste means waste like paper, cardboard. xPackaging foils, bulky waste, residual waste, plastic and organic waste. It does not include liquid waste and dangerous substances.

Step 3: Please identify which waste processing is/are used at your airport:

(see diagram)

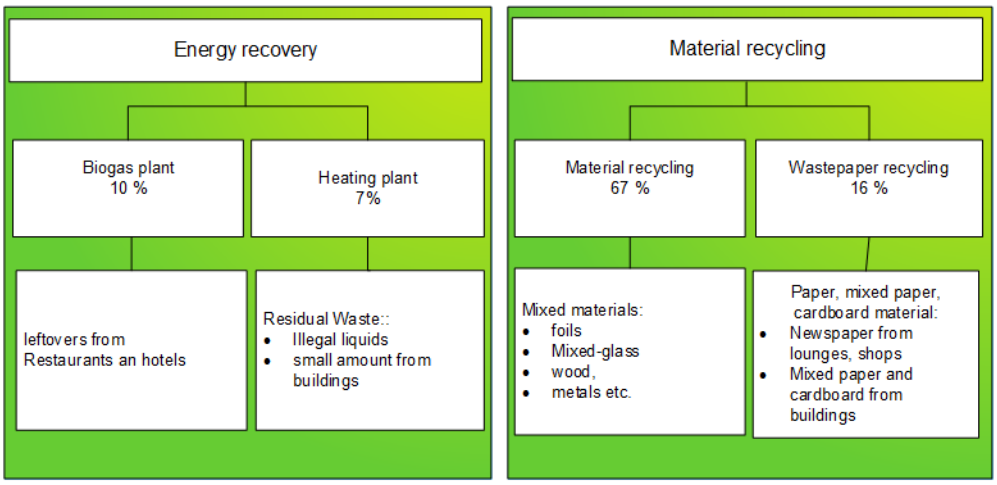
(x) Recycling

(x) Waste Recovery (e.g Waste to Energy)

(x) Incineration

( ) Landfill

( ) Other _____



Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(2) Environmental

(5) Political

(4) Social

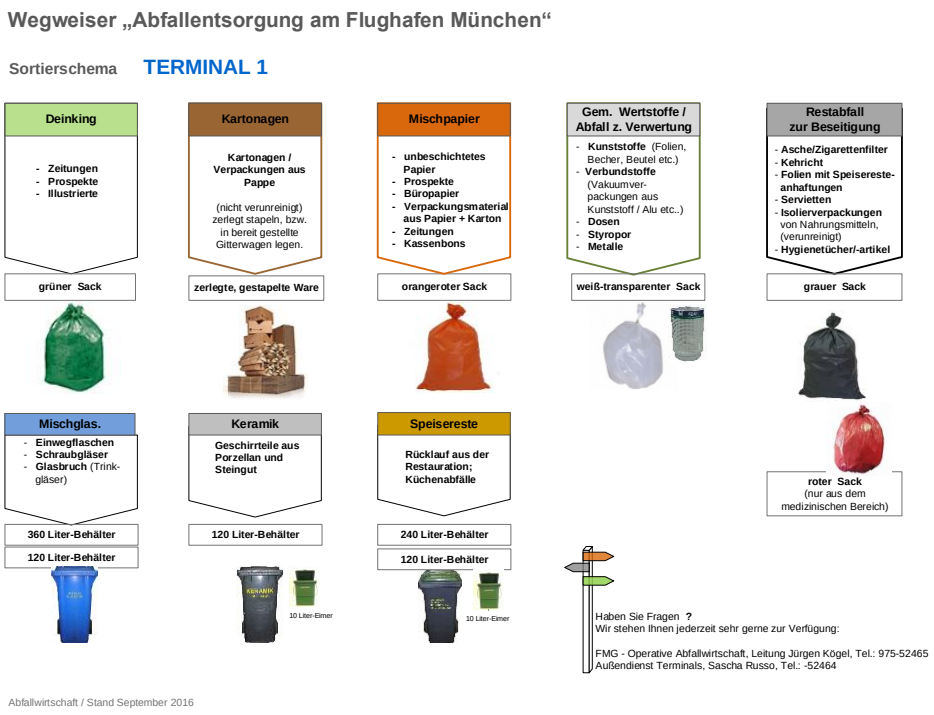
(1) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

The accounting process is to be based on different waste fractions, depending on the collected volume and using different prices. In this way, the customer can influence his own waste disposal costs in future by avoiding ad sorting waste.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?



Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

A certified company for the disposal of solid waste and a Disposal Company who empties Waste containers when requested. As raw materials are becoming increasingly rare and more valuable, a reliable and sustainable Disposal Company should be chosen as contracting partner.

Step 8: Which department is in charge of waste management in your organization?

Waste Management Group at Munich Airport

The task of the Waste Management Group at Munich Airport is to assure that waste produced on the airport premises is properly disposed of or recycled according to the statutory regulations.

The waste management serves as a connecting link between the Clients and the Disposal Company. Amongst other things the aim of this cooperation is to offer an economic waste disposal to the Clients, but also to ensure that everything runs out environment-friendly and for the best to the airport’s reputation.

Step 9: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

According to the hierarchy of the German Closed Substance Cycle and Waste Management Act

Estimated Cost and Financial mechanisms available:

Compared to disposal, the recovery of waste gains cost reduction. This becomes even clearer when having a closer look at the fact that the disposal costs differ greatly depending on the type of waste.

For example, proceeds of 80 €/Mg are generated by newspapers. Disposal costs of 219 €/Mg have to be paid for residual waste.

Images:

Waste collection room – Terminal 1

Results (Environmental Benefit/Cost Benefit):

By performing an analysis of recyclable material, referring to mixed recyclables, the potential for recycling can be increased and in consequence costs for disposal can be reduced.
In addition to that: Short distances to the disposal companies means low energy consumption for transport and help to reduce CO2-emission.

Lessons Learned:

With this waste management process it is possible on increasing the recycling ratio of waste and on the other hand to reduce costs for waste disposal. It is therefore mandatory to sort the waste in the best way possible. In addition to sorting waste it is necessary to bill the customer/producer of waste for his personal waste amount and sorting quality.

Waste, which is sorted in high quality, can reach high prices in negotiation on the recycling market. Economic and ecological targets are not necessarily in contradiction: with the waste management process at Munich Airport it is possible to save money AND resources.

ECO AIRPORT TOOLKIT

Schiphol Airport: Light as a Service

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Denise Pronk
Organization/Company	Royal Schiphol Group
Job Title	Programme Manager Corporate Responsibility
Email Address	Pronk_d@schiphol.nl
Telephone	0031 6 538 27742
Airport *(Name and 3 Letter Code)*	Schiphol Airport / AMS

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Light as a service

Timeframe (e.g., start and end month/year if applicable):

Description:

Philips (supplier), Engie (maintenance partner) and Schiphol joined forces on this exciting programme. All were inspired by a shared vision and ambition. Philips and Engie adapted fittings in consultation with Schiphol, making it possible to replace separate components with ease, which extends the service life of the lighting. When lamps have reached the end of their service life, Philips will collect and recycle them.

Purpose:

Schiphol believes in a circular economy and wants to play an active role in making it happen. Schiphol entered into a partnership with Engie and Philips to replace the lighting fixtures in its terminal. Schiphol will pay for light performance while Philips remains the owner of the fittings and installations. Philips and Engie are responsible for the system's performance and service life. By applying various circular economy principles, Schiphol, Engie and Philips are setting a new standard for the worldwide transition to a circular economy.

Step 3: Please identify which waste processing is/are used at your airport:

(X) Recycling

( ) Waste Recovery (e.g Waste to Energy)

( ) Incineration

( ) Landfill

(X) Other: Circular Economy; maintenance _____

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Economic

(2) Environmental

( ) Political

( ) Social

( ) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Our traditional business models are based on the linear model of take-make-waste. To create a circular future, the models had to be adapted according to the principles of the circular economy. As a result, the contracts and partnerships with our suppliers changed, too. A challenge that cost time and perseverance to get everyone on the same page.

In this case, Engie performs the maintenance whilst Philips is responsible for taking back the lamps. The 'light as a service' concept entails that Schiphol pays for the light produced, while Philips and Cofely remain the owners of the lamps and fittings (pay per use).

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

Not applicable

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

Philips – supplier; Engie – maincontractor maintenance terminal. Together, Philips and Engie ensure real-time lighting management for optimum effect and sustainability, with Cofely's on-site, round-the-clock support. At the same time, they monitor intensity and reliability by applying a KPI model.

Step 8: Which department is in charge of waste management in your organization?

Asset management

Step 9: Please insert Text and Images of your project/case study below here:

Decision-Making Process: Investment decision, proved by Management Board.

Estimated Cost and Financial mechanisms available:

Images:

Results (Environmental Benefit/Cost Benefit):

- Unique lighting plan for significantly improved sustainability, feel and flow 50% reduction in energy consumption thanks to energy-efficient LED lighting.
- 75% longer service life of the fittings.
- Decline in maintenance costs – components of fittings can be replaced separately. Adapted fitting rates 19% higher on circular economic score card and service life is extended by 75%.
- Maximum reduction of raw material consumption – complete fittings can be reused.
- New business model for putting circular economic principles into practice. KPI model is included in a contract for performance monitoring.

Lessons Learned:

- Dare to try something different.
- Opt for a large-scale project to have an immediate impact and truly learn something.
- Ensure you have a very clear, shared vision and goal that consistently provides direction and a point of reference.
- Ensure your business partners have a shared vision about the end state. The way how to get there is difficult, so a clear joint ambition is crucial.
- Build mutual trust and dare to go beyond the traditional supplier-purchaser relationship.
- Put together a team of people who are interested in innovation.
- Invest a great deal of time and energy in stakeholder management.
- Excellent management support is key to success.
- Strike the right balance between the sustainable and business cases.
- Persistence pays.

ECO AIRPORT TOOLKIT

Vancouver International Airport: Waste Management at YVR

Waste Management at the Airport site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco-friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Shaye Folk-Blagbrough
Organization/Company	Vancouver Airport Authority
Job Title	Environmental Specialist
Email Address	Shaye_Folk-Blagbrough@yvr.ca
Telephone	604-276-6710
Airport *(Name and 3 Letter Code)*	Vancouver International Airport (YVR)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Waste Management at YVR

Timeframe (e.g., start and end month/year if applicable): January 1, 2015 – ongoing.

Description:

Vancouver Airport Authority (Airport Authority) is a community-based, not-for-profit organization, which manages Vancouver International Airport (YVR) under the provisions of a long-term ground lease with the Government of Canada. YVR is located in the City of Richmond within the region of Metro Vancouver, in British Columbia (BC) Canada. YVR is the second busiest airport in Canada and in 2017 hosted over 24.1 million visitors. YVR's operations includes two terminals, specifically the main terminal comprising a domestic terminal building (DTB), and the international terminal building (ITB), a small satellite terminal, as well as several off-site administrative offices, plus multiple businesses and retailers.

The Airport Authority's mandate is to manage and operate YVR in the best interests of the region, expand the contribution that YVR makes to local economic development, and ensure that the airport can respond to the demands of the community and aviation industry in a safe, efficient, and environmentally responsible manner. As part of the Airport Authority's 2015-2019 Environmental Management Plan, one of the four key strategic priorities is to divert 50 per cent of total waste generated at YVR (from the DTB and ITB) from going to landfill by 2020. From 1992 to 2014, YVR's waste diversion rate ranged from a low of 9 per cent to 36 per cent with difficulty in moving past the latter value.

- YVR has a multi-stream waste and recycling system enabling staff and visitors to recycle a variety of materials. However, the corporate goal of 50 per cent waste diversion rate includes the airport's four primary recycling streams collected from the DTB and ITB. These include:
- Mixed containers (glass, metal, plastic);
- Paper and cardboard (including coffee cups);
- Pallets and clean wood; and
- Organics (food scraps, paper towel, and food soiled paper)

Additional areas that are not reflected in the 50 per cent diversion rate, but are still readily recycled include:

- Construction waste (YVR achieves a 97-98% recycling rate);
- Extended Producer Responsibility (EPR) program materials including lightbulbs, batteries, and electronics;
- Kitchen grease;
- Latex gloves;
- Wooden chopsticks;
- Landscape materials; and
- Food donations.

Purpose:

Step 3: Please identify which waste processing is/are used at your airport:

(✓) Recycling

(✓) Reuse – reuse of chopsticks collected at food courts. See explanation below.

( ) Waste Recovery

( ) Incineration – YVR does not have any waste sent for incineration. For airlines all non-domestic flights and the operations associated with them (and pre-customs areas within the Terminal) are currently required to incinerate all waste as per the Canadian Food Inspection Agency International Waste Directive. Airline waste at YVR is not under the purview of the Airport Authority and is the responsibility of the airlines to manage.

(✓) Landfill

(✓) Other On Site Composter (treating organic waste)

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(4) Economic

(1) Environmental

(1) Political

(1) Social

(1) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, were there any available incentives for the development of such programs? Can you describe it?

There were no financial incentives for YVR to further develop its waste management program. However, there were a number of key drivers that included:

- Regulatory environment
- Corporate goals
- Business case
- Corporate value: innovation

REGULATORY ENVIRONMENT

Metro Vancouver, the region's solid waste regulator, introduced a disposal ban regulation on compostable organic material to help achieve the provincial waste diversion target. The regulations stipulated that waste transfer stations would not accept waste loads going to landfill with organic material greater than 25 per cent and the originator of these loads would be subject to a financial penalty. In response and to comply with this organic waste ban, institutions and businesses operating in the region have been required to source-separate organic material (i.e., food scraps, food soiled paper and clean wood) from the garbage stream.

CORPORATE GOALS

In 2014, the Airport Authority approved a five-year Environmental Management Plan (2015-2019). The Environmental Management Plan was aligned with the Airport Authority's new Strategic Plan's objective to be a leader in sustainability. With corporate leadership stating change, a number of new environmental targets were publically set to reduce the airport's environmental footprint, including the adoption of a goal to cut waste going to landfill to 50 per cent within the plan's time frame.

BUSINESS CASE

To address stated waste (environmental) goals, the Airport Authority expanded its business case to ensure that sustainability pillars — environment, social, financial and governance — were embedded into all airport projects. The shift in business at the corporate level has trickled down to all airport departments ensuring that waste targets are no longer the sole responsibility of the Environment Department. The Environment Department remains the office of primary responsibility for the airport's waste target. However, all Airport Authority departments are accountable with the consideration of waste as a priority for all airport projects.

CORPORATE VALUE: INNOVATION

Prior to the adoption of the 2015–2019 Environmental Management Plan, waste diversion was not top-of-mind for most of the Airport Authority's departments. This level of ownership had been sufficient for the waste goals of the past, but to improve performance and meet the new corporate goal of 50 per cent waste diversion by 2020, the Airport Authority embedded innovation as one of four core values. Interdisciplinary teams have worked on identifying barriers to change and brainstormed potential and innovative new instruments to drive improved waste diversion.

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

The Airport Authority is required to adhere to the Government of Canada's requirement to provide all signage in both English and French, Canada's two official languages and with a large international passenger complement, the use of pictograms rather than words provides greater clarity and simplicity in the development of waste bin signage. YVR follows the regional government, Metro Vancouver's,, recommended colour scheme for waste separation (see below). Though most businesses and cities are using a similar colour scheme, there are no national regulations or standards on colours and labels that should be used in regards to waste diversion.

Waste Stream	Colour
Garbage (Landfill)	Black
Compost	Green
Containers	Blue
Paper	Yellow

In addition to the colour scheme, the Airport Authority has included symbols of accepted products at the front of each bin so that it can be easily identified. All bins located throughout YVR are placed in a consistent bin order; paper, containers (plastics, metals and glass), compost/organics and landfill.

The standardization of waste reduction communication efforts, such as signage and branding, ensures that the messaging is understood and recognized by passengers. YVR chose the colour scheme as it reflects the regional colour scheme adopted by Metro Vancouver. This is meant to provide consistency for most users of the airports, as the majority of passengers at YVR are domestic.

While the international harmonization of labeling/colour codes for waste separation would have its benefit, it would need to be well-researched to ensure YVR could target all passengers effectively.

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

YVR's waste management program's success can be attributed to a strong stakeholder engagement program. To achieve YVR's waste diversion target, required a collaborative effort of internal staff, as well as external stakeholders including third-party waste contractors, airport business partners, food and beverage tenants and housekeeping staff who have a role in how waste is managed at YVR. Improved recycling is behaviour focused and requires education, interaction and ongoing reinforcement.

Step 8: Which department is in charge of waste management in your organization?

The Environment Department is the office of primary responsibility for the waste diversion target at YVR. However, all departments are accountable to the program and must consider waste in projects.

Step 9: Please insert Text and Images of your project/case study below here:

Estimated Cost and Financial mechanisms available: minimal

Communication and engagement programming

- Talkin' Trash Articles

Talkin' Trash is series of electronic articles posted on the Airport Authority's internal web portal to educate and inspire employees on all things waste-related. Topics have ranged from waste sorting and the circular economy to interesting waste facts and how to reduce waste generation at home and in the office.

- Recycling Spot Checks

The Airport Authority conducts regular informal "spot" recycling back-of-house inspections at all food and beverage establishments at the airport. This is an ongoing and routine initiative that ensures the Airport Authority continues to educate and reinforce the airport's waste diversion goals.

- Green Bins

To assist restaurants in setting up their own organic waste systems within their kitchens, the Airport Authority distributed compost "green bins" and provided educational materials on what was allowed and not allowed in the compost bins. The Airport Authority provides continuous support to restaurants in helping them overcome their organic waste challenges through bin replacements, education and signage to improve organics recycling.

- Waste Wars

To support acceptance among tenants and to reduce cross-contamination of all food and beverage in the waste streams, the Airport Authority developed an educational engagement program, called 'Waste Wars'. Waste Wars was designed as a friendly and voluntary competition encouraging food and beverage tenants to sort their waste properly and avoid contamination of recyclable materials in garbage and vice versa. The objective of the competition was to engage tenants while improving their waste separation skills. Waste Wars rules are simple: organic waste belongs in the green bin; plastics, paper and metals in the recycle bins; and the remaining waste in the garbage. Every week, during Waste Wars, each food and beverage tenants' bins are inspected and the tenant is allocated points based on the level of appropriate separation. Along with the inspections, staff is quizzed on their recycling awareness for extra points. At the conclusion, the tenant with the highest point allocation is announced as the winner and is profiled in various media in recognition of their efforts.

WASTE WARS

May the best bin win!

- Presentations on Waste Diversion

The Environment Department discusses waste with stakeholders at any opportunity. The team conducts several waste reduction presentations for both internal and external audiences, including the following:

- YVR Environmental Advisory Committee
- All Concessionaires Meetings
- YVR All-Employee Meeting Presentations

Waste Reduction Week

Airport Authority observes Waste Reduction Week, an annual event held during the third week of October to raise awareness of waste reduction across Canada. To celebrate this annual event and raise awareness of waste reduction, the Airport Authority has organized a household object and clothing donation drive; held a film screening of "The Clean Bin Project" - a zero-waste documentary; providing daily information articles on how to engage in a reduced waste lifestyle; and hosting a zero-waste lunch contest to name a few.

- Chopstick Recycling

Due to the high number of restaurants using chopsticks at YVR, the Airport Authority partnered with ChopValue Manufacturing, a Vancouver-based engineering and design company that creates innovative material repurposing used chopsticks. Chopsticks once used as cutlery at YVR are given a new life and repurposed into trophies for YVR's Waste Wars.

Design & New Technologies

Estimated Cost and Financial mechanisms available: n/a

- Composter

The Airport Authority is constantly seeking other new and innovative ways to improve waste management at YVR. The Airport Authority installed its first in-house composter in the International Food Court in the Main Terminal Building. The composter:

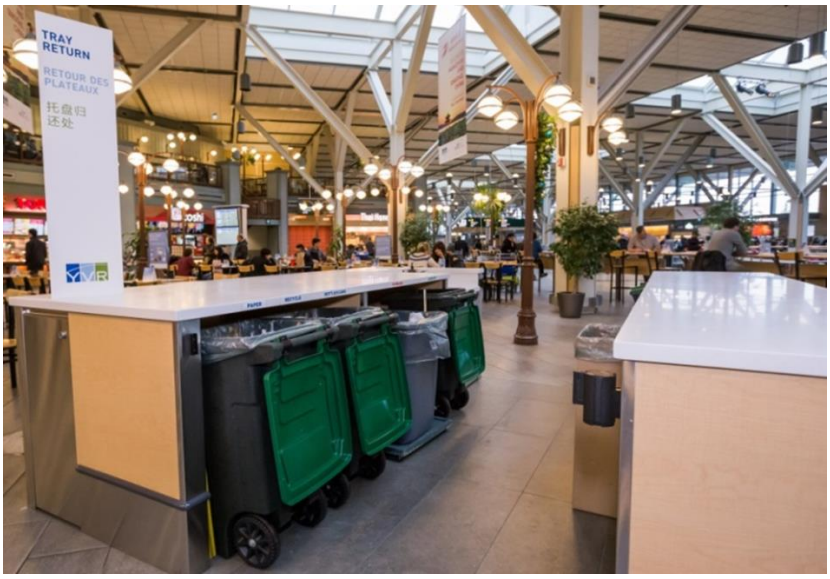
- Reduces the amount of organic waste to be collected and removed from International Food Court by up to 80%.
- Reduces the amount of organic waste material needing to be trucked offsite. This reduces truck traffic resulting in fewer GHG from transportation of the material off-site.


c

The in-house composter in the International Food Court

- Centralized Food Court Sorting Station

To improve the sorting of waste in food courts at YVR, the Airport Authority took the action of sorting out of the passenger's hands. The Airport Authority installed a centralized sorting station at one the airport's busiest food courts. With this new station, patrons leave their trays on the counter for trained airport staff to sort into the different waste streams. This prevents any confusion and ensures that waste is being diverted into the proper stream while improving customer service. The sorting station has resulted in improved diversion rates and a reduction in garbage.



Centralized food court sorting station

Results (Environmental Benefit/Cost Benefit):

Infrastructure changes – the composter and centralized food court station - have been the largest cost to the overall program; however operational cost savings were identified. The community engagement component of the program costs have been small with staffing being the largest resource and critical to its success. With the combined efforts of the Airport Authority, its business partners and tenants coupled with the various supporting waste reduction programs, engagement initiatives and technologies, YVR achieved a waste diversion rate of 51 per cent in 2016, three years ahead of stated goal.

Lessons Learned:

YVR's waste program has worked on improving culture, introduced programming and installed innovative new designs to advance our waste management goals. Community engagement is the primary focus of the program and is very cost affordable and has been proven to be successful in terms of achieving our waste diversion goal of 50 per cent by 2020, three years earlier than targeted. It is also through engagement that new and positive relationships are being built between the Airport Authority and airport tenants. Educating and supporting tenants are where immediate gains can be observed. Minimal capital costs have been incurred for the waste program at YVR because it is felt that waste is behavioural (and with slight alterations in infrastructure) and supporting desired behaviours is paramount to success. Going forward, the Airport Authority is excited to continue to be innovative and strategic in advancing new waste diversion initiatives, working in collaboration with its partners into the future.

ECO AIRPORT TOOLKIT

Gatwick Airport Limited: Circular Economy Waste Management Strategy

Waste Management at the Airport Site

A request for case studies

Description of Request

ICAO's Committee on Aviation Environmental Protection (CAEP) is currently developing an *ECO Airport Toolkit*, with the objective to provide supplementary information on selected topics included in the recently updated ICAO Doc 9184 *Airport Planning Manual, Part 2, Land Use and Environmental Management*. The "e-publications" are intended for use by airport operators, States and regional and local authorities that are planning or engaged in airport infrastructure projects, particularly in regions in which the aviation sector is developing strongly.

This request is for airport operators to use the below template to provide examples of eco- friendly waste management at the airport site. We are particularly interest in good waste management practices including creative approaches of reducing waste consumption and engaging different stakeholders. The selected studies are going to be included as annexes to the ICAO e-publication Waste Management at the airport site.

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	
Organization/Company	Gatwick Airport Limited
Job Title	
Email Address	
Telephone	
Airport *(Name and 3 Letter Code)*	LGW

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:
Timeframe (e.g., start and end month/year if applicable): May 2016 – March 2018 – Contract start to project completion / close out

Description:
Gatwick encompasses over 120 airport operational and commercial businesses which use and provide - to other businesses or to passengers - a wide range and large volume of materials every day. The Airport is

also undergoing a major development and refurbishment transformation. All of these activities generate leftover materials that can – some easily, others only with systemic innovation – be reduced, reused or recycled. Our Decade of Change goals, set in 2010, are to achieve zero untreated waste to landfill and 70 percent reuse and recycling for operational and commercial waste by 2020. We achieved zero to landfill which has been maintained continuously since May 2015. Progress on the second goal has been more incremental, with reuse and recycling increasing from 40% at the start of the decade to 49% in 2015 and 52% in 2016. This is above average performance in the UK but we wanted to do much better. In 2015 therefore we set out to change the way 'waste' is regarded and processed at Gatwick.

Our aim was to redesign and implement a waste management strategy focussing on a "Circular economy" ethos of utilising as many recovered resources as possible within the Airport campus. The project included redeveloping the collection facilities, a new approach to waste logistics and an on-site organic energy from waste system to deal with highly regulated international catering waste

Areas of focus and investment included;

- Gatwick upgrading the waste away areas
- Gatwick investing in a MRF recycling facility
- Gatwick investing in a biomass boiler Purpose:

The project encompassed a "root and branch" review of waste management and handling practices across the Airport, in addition to identifying opportunities to utilise resources more effectively across the campus. The resultant project has delivered an immediate uplift in conventional recycling, whilst allowing valuable resources such as energy and water to be harvested and put to use within the Airport.

A key focus throughout this was waste minimisation (following the waste hierarchy) and having futureproof processes in place to ensure no waste goes directly to landfill and Gatwick Airport maximises the opportunity to recycle and re-use all of its commercial and airline cabin waste.

Step 3: Please identify which waste processing is/are used at your airport:

(X) Recycling

(X) Waste Recovery (e.g Waste to Energy) ( ) Incineration

( ) Landfill

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the waste management project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(X) Economic

(X) Environmental ( ) Political

( ) Social

(X) Regulatory

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, were there any available incentives for the development of such programs? Can you describe it?

A key commitment was for the Airport to achieve an overall recycling rate of 70% by 2020. Conventional recycling best practice had already achieved a recycling performance of 42% by 2014 however to achieve 70% the Airport Management realised that a step-change would be needed. In November 2015 Gatwick's Capital Executive Committee (CEC) approved a £4m capital investment over 2 years for a new waste management facility. In May 2016 Gatwick awarded DHL the waste management contract and to implement the changes required following a competitive OJEU tender which had innovation at the heart of its requirement.

The deliverables from the investment would be seen in:

- Providing better areas and equipment to segregate waste at source
- Reducing the vehicle movements and handling of waste
- Further segregation of waste on site at the recycling centre
- Recycling / re-use of CAT 1 & CAT 3 airline cabin waste and food waste

Step 6: Could you please describe your labeling/colour coding to waste separation? Is this based on national regulation? Do you think you could benefit from international harmonization of labeling/colour codes for waste separation?

Mixed recycling facility:

The Facility includes a manual waste sorting conveyor which began operating in September 2016. Together with reclassification of waste streams into 'Dry' and 'Wet', onsite sorting is
lifting the Airport's reuse and recycling rate to 60% in 2017 and above 75% by the end of 2018. In addition, by using small balers at our Terminals and large 'mill size' bales to compress waste, there are 200 fewer industrial-size waste bin collections per day at the Airport, reducing lorry vehicle journeys to external waste plants

Bio Mass boiler:

The Facility is the first at any airport in the world to process Category 1 airline waste onsite and convert it to low-carbon energy. Category 1 waste comprises food waste and anything mixed with it from non-EU flights. Its disposal is governed by strict rules that require specialist processing (until now, offsite) to protect against potential spread of disease and infectious
material. Around 20% of the Airport's operational and commercial waste is Category 1. To treat this waste, and other wet waste that cannot be recycled, the new Facility incorporates an onsite dryer and biomass boiler. The waste is dehydrated and turned into solid biomass fuel which is used to generate heat for the dryer and for the Facility buildings. Water recovered from the waste-drying stage is also used to clean waste bins, helping to reduce Airport water consumption by 2 million litres per annum. The biomass boiler has been designed to operate to emission standards that are stricter than required by EU regulation. The Facility is set to save £1,000 in energy and waste management costs for every day it operates.

EU and CAT 1 Waste Labelling:

Since summer 2015 Gatwick has been working closely with the airlines cleaning contractors and DEFRA (Animal Health) to implement a working process so Gatwick Airport can identify waste coming from the

EU or if it's Category 1 waste. As mentioned above there are strict regulations around the disposal of CAT 1 waste (or unclassified waste off an aircraft). It's great that CAT 1 waste can now be processed on site but by working through a process to identify EU bags (which aren't considered a risk), Gatwick can process these down the mixed recycling facility line and extract the valuable recyclables from these bags.

Step 7: Did you engage with internal and external stakeholders? If so, please identify which stakeholders you engaged with.

Legislative:

- There was a requirement to address and speak with the local environment agencies, local council and DEFRA early on in the process as there were complex regulatory environmental guidelines covering the operation and there was no single regulatory point of contact

Operations & Airport Campus:

- There were challenges at the airport which we were trying to address and therefore the involvement with other departments (EHS, Terminals, Airfield Op's, Fire etc) were key to making sure all of their requirements were included.
- Gatwick airport has over 30,000 working staff members from various organisations who operate on site and would be using the waste facilities so it's important they were made aware and process changes were communicated.

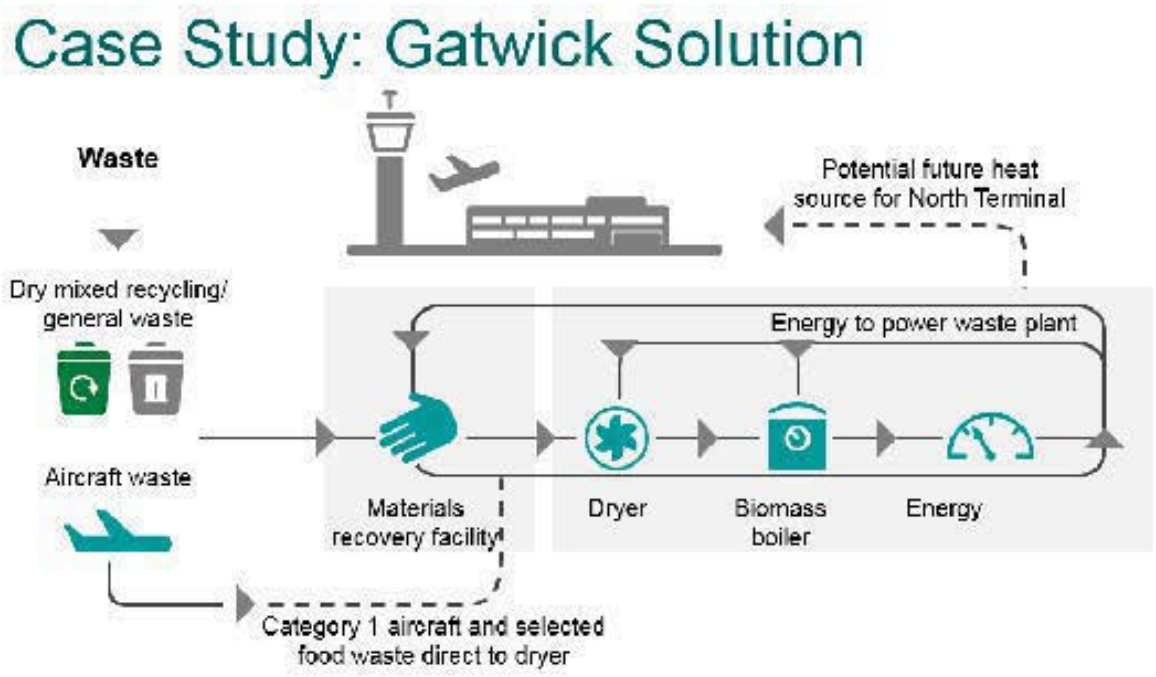
Step 8: Which department is in charge of waste management in your organization?

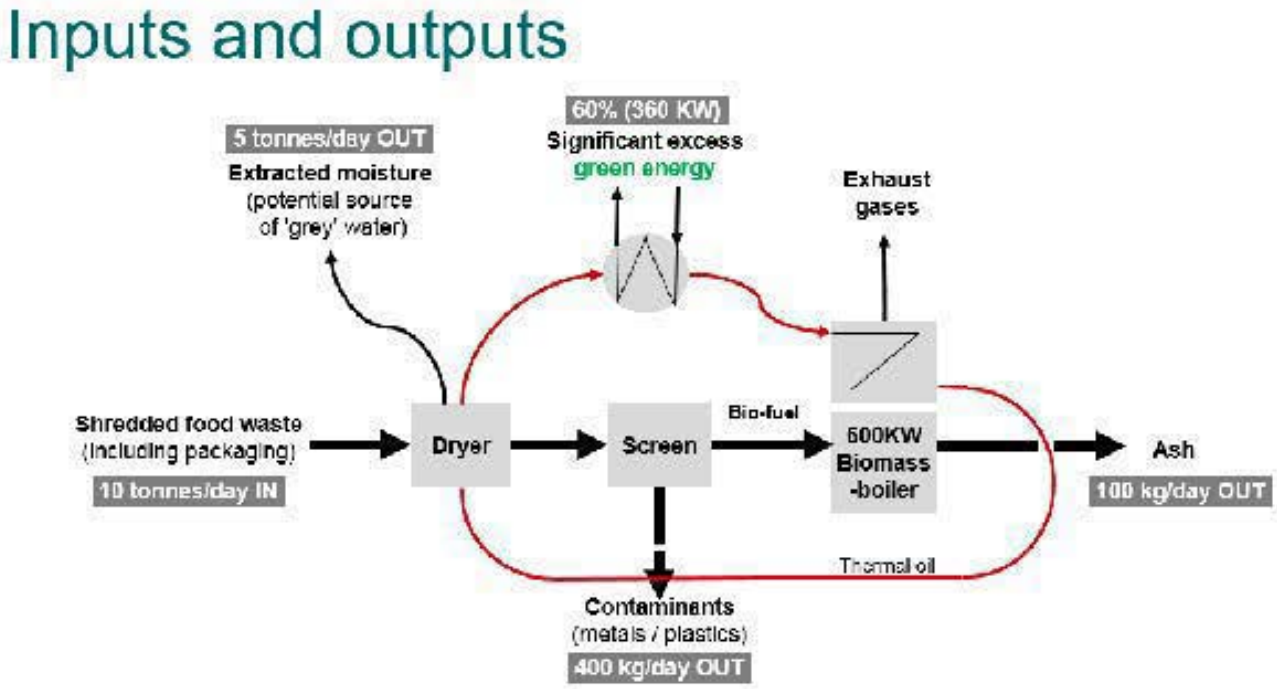
At Gatwick Airport, Waste Management is managed in our Stable Operations department by our Senior Logistics Manager. They oversee the day to day operation and are responsible for maintaining compliance. The EHS department and our Sustainability Manager will have close links into the operation supporting and managing duty of care audits, external audits and driving our decade of change target.

Step 9: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

Estimated Cost and Financial mechanisms available: Images:





Results (Environmental Benefit/Cost Benefit):

Impact on recycling performance

- 30% Improvement in recycling following the implementation of the MRF (mixed recovery facility) since 2016
- 428 Fewer waste collections per annum

- 2 million litres of grey water harvested from the Biomass Boiler per annum
- 4.75 Million KWH of reusable heat energy from the Biomass Boiler per annum
- On target to achieve Decade of Change recycling rate early in 2018, two years before deadline (70% recycling and re-use)
- Expected 2020 performance circa 85% recycling
-

Waste Minimisation

- Grey water extracted and discharged for recovery
- Combustion reduces organic fraction to ash
- Only screened contaminants and ash are sent for disposal

Financial

- Estimated £700K+ saving in disposal costs per annum

Lessons Learned

— — — — — — — —

Solid Waste Management in Lebanon: Challenges and Recommendations JEWM Solid Waste Management in Lebanon: Challenges and Recommendations

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Research Article

Solid Waste Management in Lebanon: Challenges and Recommendations

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Successful waste management plans require accurate data about the nature and composition of waste. Despite the high content of organic (52%) and recyclable (37 %) materials in waste stream, only 8% and 15% of solid waste are recycled and composted respectively. Unfortunately, 48% of the waste are disposed in sanitary landfills. Dumping of waste and open burning is predominant outside Beirut and Mount Lebanon. Adequate treatment is unavailable for wastes produced by slaughterhouses, industrial premises and healthcare centers. Corruption, lack of human resources and suitable facilities and inadequate technical skills are responsible for inefficient municipal solid waste management. This paper aims at determining the current practices of municipalities in terms of segregation, collection, treatment and final disposal of solid waste. It also considers key policy challenges and recommendations for improving the municipal solid waste management system.

Key Words: Solid Waste Management, Recycling, Composting, Incineration, Landfill.

INTRODUCTION

Waste generation in Lebanon has increased significantly during the past decades. This is mainly due to the rise in community living standards, urbanization, immigration of Syrian refugees, and increasing in population levels (Cohen, B. 2004; MOE, 2014). Solid waste management (SWM) is critical in protecting environment and ensuring human health. Therefore, new strategies are needed to deal with the waste Lebanese produce today to prevent it from creating problems for next generations. In the last few months, Lebanon witnessed a waste management crisis which results in the scattering of satellite landfills and incineration sites throughout the country, with grave consequences on health, economy and environment (Sara, 2015; Giusti, 2009; Naharnet Newsdesk, 2016; Coffey, 2010). For the first time, dioxin and Dibenzanthracene compounds were identified in air in Lebanon (Massoud 2016). These toxins have the potential to raise the lifetime of cancer risk (Aderemi, 2012; Mazz, 2015; Thamaraiselvan, 2015) and may cause lasting ill effects on human health and environment (Khairy, 2009).

Although Lebanon practiced a string of SWM plans (Halldin, 2010; MOE, 2011) over the last 20 years, SWM has remained a complex task. This is due to deficiency in skills of modern SWM practices (Boadi, 2005; Vitorino de Souza, 2017), lack of awareness on the threats of unsustainable waste management practices (Henry, 2006), and poor Government support (Konteh, 2009). Private sector has failed to shift from high percentage of disposal to recovery of both energy and materials (CDR/LACECO, 2011).

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Table 1: Background information about waste in Lebanon (MOE, 2014)

Population	5,600000 Lebanese + 2500000 refugees
MSW Generation	2.04 million tons
- **Urban Areas**	0.95-1.2 Kg/day
- **Rural Areas**	0.8 Kg/day
MSW Generation Growth	1.65 % per year
Medical Waste	25040 tons/year
Industrial Waste	188850 tons/year
Slaughterhouses Waste	40000 tons/year

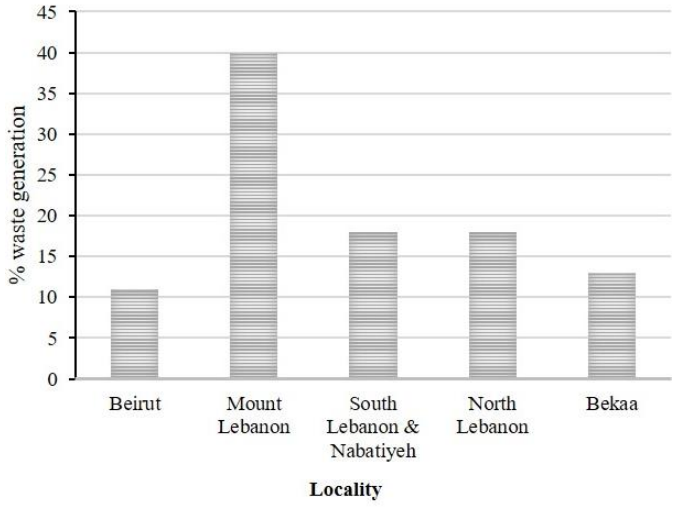

Figure 1: Waste generation per locality (GIZ, 2010).

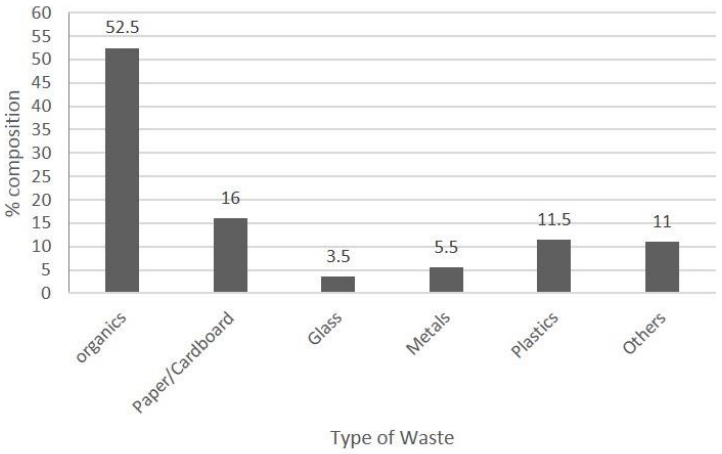

Figure 2 Waste composition in Lebanon. (MOE, 2014; Massoud, 2016)

On the other hand, municipalities are facing main problems such as lack of organization, and financial resources (Parthan, 2012), Consequently, high percentage of Lebanon's solid waste still ends up in landfills and open dumps (MOE, 2011). The current waste problem could be resolved by adopting an integrated sustainable waste management strategy. Thus, the main objectives of the study are to determine the current practices of municipal SWM in Lebanon in terms of segregation, collection, treatment, and final disposal; assess the level of services and allocation of financial and human resources in SWM; and identify key policy challenges and recommendations for improving municipal SWM in Lebanon.

MATERIALS AND METHODS

Quantum and Nature of Solid Waste

The properties of municipal solid waste (MSW) collected from different places in Lebanon depend on many parameters such as consumer patterns, food habits, the cultural traditions of citizens, lifestyles, climate, and economic status. As the cities expand, average per capita waste generation increases. Waste generation is 1.05 Kg per capita per day in Lebanon amounting to about 2.04 MT of waste annually (Table 1). Also, lifestyle changes are leading to the use of more packaging materials and as such waste generation is increasing by about 1.65 % per capita per year (MOE 2014). Lebanon is divided into five localities: Beirut, Mount Lebanon, South Lebanon and Nabatiyeh, North Lebanon, and Bekaa. Contribution of each district to the total stream of solid waste is presented in Figure 1.

Various research studies have been conducted on the composition of the MSW stream in Lebanon since 1995 (Figure 2) (MOE, 2011; Massoud, 2016). Analysis of waste composition indicates that the highest waste fraction is organic matter (52%), followed by papers and cardboards (16%), plastics (12%), others (11%), metals (6%) and glass (3%). The high organic content suggests the frequent collection and removal, as well as good prospects for organic waste resource recovery. The content of major reusable and recyclable materials (i.e., plastic, paper and paper products, metal and glass) comprised 37% on average. It is also notable that the composition of municipal waste varied greatly among different locations in Lebanon. Organic content at the national level (52 %) may be lower than in Beirut (63%) because people feed some of their organic wastes (vegetable cuts, fruit remains, etc.) to their domestic animals in rural areas. MSW makes up about 89 % of the total solid waste stream generated in Lebanon (Figure 3).

The main sources of MSW are households, commercial establishments, street markets, street cleaning operations,

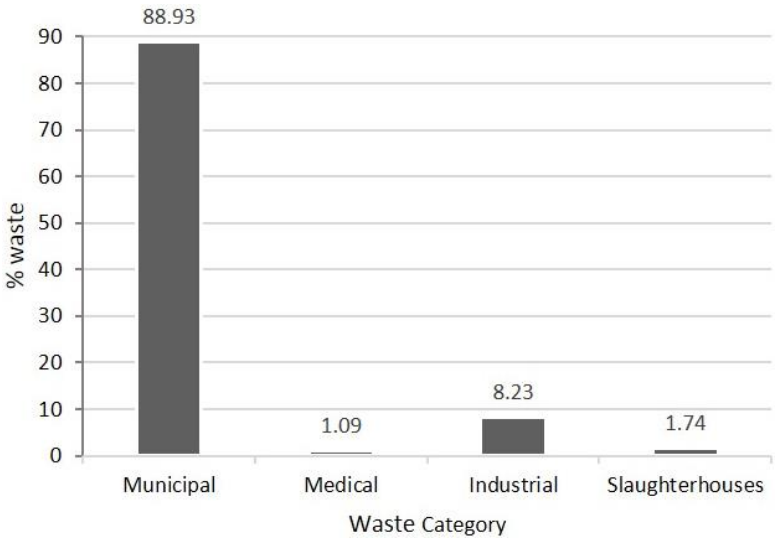

Figure 3 Waste categories in Lebanon. (MOE, 2014)

Table 2: Duties of different stakeholders (MOE, 2011; Massoud, 2016)

Stakeholder	Main Responsibilities
Waste Management Board	Developing waste strategy and authorizing waste management plans
Ministry of Environment	Initiating waste management standards and guidelines and implementing waste management programs
Ministry of Interior and Municipalities	- Participation in the National Strategy and plan and implementation of local waste management plans - Establishing/ implementing waste management programs
Municipalities	- Participation in the National strategy and plan through the Waste Management Board - Proposing and implementing local waste management plans for non-hazardous municipal waste - Establishing / implementing waste Management programs - Management of waste collection
Council of Development and Reconstruction	- Assistance in procurement of WM projects upon request - Assistance in the development of WM plans upon request
Private Sector / the Public	- Abiding by laws, regulations and guidelines on waste management - Prohibition of littering, illegal bumping and burning - Participation in the National strategy and plan through the Waste Management Board - Participation in the development and implementation of local waste management plans - Participation of facility and generator management plans

and fields' trimming. As far as the industrial waste is concerned, about 22,000 industrial companies produce a wide range of solid wastes which contribute to about 8.23 % to the total solid waste stream in Lebanon (GIZ, 2010). Non-hazardous wastes (packaging, Styrofoam, wood pallets, food residues, etc.) comprise 98.2 % of the industrial waste stream. The remainder fraction however is potentially hazardous, as defined by the Basel Convention (www.basel.int).

The composition of Lebanon's industrial waste is poorly documented and no plants are available for industrial waste treatment. In the absence of a well-defined legislation and more stringent controls, most of the industrial and hazardous wastes are mixed with the municipal wastes. Additionally, wastes produced by slaughterhouses contributes to 1.74 % of total waste generation (MOE, 2011). Furthermore, waste stream composes of 20 and 79.8 % of infectious and non-infectious healthcare wastes respectively.

Finally, there are currently no facilities for recovering used tires. Within Sukleen's service area, used tires are collected as part of the bulky waste stream and stored at the warehouse. A small portion is then resold to tire recycling customers while the remaining portion is shredded and sent to Bsalim landfill to be used as inert material (GIZ, 2010). Outside Sukleen's service area, used tires are either (1) stockpiled in various locations (mainly near vehicles repair shops), (2) dumped haphazardly, (3) used as solid fuels for home heating, and/or (4) burned.

Stakeholders

Stakeholders usually have different interests and play different roles (Zarate, 2008). The key stakeholders and their duties in MSW management are listed in Table 2 (MOE, 2014; Massoud, 2016). Stakeholders' involvement is a key factor for the success of SWM. Government is considered as the most important stakeholder which set up policies and the provision of SWM system. The private

contractors are also considered as essential stakeholders as well as the facility users such as: households, civil organizations, industrial and commercial sectors. The less important stakeholders are educational and research institutions, farmers, health care centers, Chamber of Commerce and Industry, recycling companies and police. MSW in main cities is mainly operated by private sector. The main roles of private sector are collection, transport, processing and disposal of solid wastes. In the capital (Beirut) and parts of Mount Lebanon, Sukleen is responsible for waste collection and street cleaning. Waste treatment and disposal are performed by SUKOMI. Waste treatment is mainly based on bailing, wrapping, transport and landfilling, with sorting and composting, and at costs which are substantially high (Mazza, 2015). In Tripoli, Lavajet and BATCO are responsible for waste collection and disposal respectively. In the city of Zahleh, the private sector is responsible for waste collection and disposal of solid waste. In Saida, the private sector built an anaerobic digester for municipal waste treatment.

RESULTS AND DISCUSSIONS

Existing Solid Waste Management System

Collection and Segregation

Collection, city cleaning, and sweeping is not performed every day except in main markets and in some residential areas. Other areas are served occasionally from twice a week to twice a month. Many areas are neglected due to the ineffectiveness and insufficiency of the service. Container service, and roadside pickup from open piles or containers are the types of collection service generally used by municipalities and private sectors.

In Beirut and Mount Lebanon, the collection of waste from curbside containers and transportation into the two sorting facilities are performed by SUKLEEN. Processing of waste at the two sorting facilities are similar. This includes weighing, manual sorting and mechanical separation of waste by trommel screen. Organics are then sent for composting at the Coral plant. Manual sorting is further practiced to remove recyclable materials. Residual waste is then baled, wrapped and transported to the Naameh Landfill (currently Costa Brava landfill). From the waste collected, around 48% goes to landfills, 15% is treated, and 8% is recycled.

Outside Beirut and Mount Lebanon, municipalities are carrying out waste management operations (collection and disposal) according to Municipal Law No. 118 (dated 30 June 1977). Some municipalities are using their own waste collection vehicles and workers and others are subcontracting the service to private sector. Waste recovery outside Beirut and Mount Lebanon is estimated at 13% percent of the waste stream (GTZ, 2010). A number of municipalities have received technical and financial aid from international development organizations to enhance their waste management services by constructing small and medium-sized solid waste recovery facilities (GIZ, 2010). Open dumping, including riverside and roadside dumping, is practiced by many municipalities.

Transport and Final Disposal

Facilities and equipment existing in municipalities affect the effectiveness of waste transfer from primary collection to processing centers or final disposal sites. Transportation of waste from the waste storage areas to the disposal site is done by a variety of vehicles such as trucks and modern hydraulic vehicles. The percentage of MSW disposed of at landfills amounts to 48 % of the total. Problems facing municipalities at present include lack of technical support, financial constraints, problems in area selection for landfilling and strong disapproval from nearby communities. Political intervention has also been practiced in many municipalities.

In Lebanon, there are two sanitary landfills and a third landfill for inert materials in Bsalim. The three landfills receive solid waste from about half of Lebanon's population. Shredded materials and rubbles make up 89 % of the waste sent to Bsalim. Recyclable materials sent for disposal include PET, dirty plastic, tins, and cardboard (plus shredded wood and shredded tires).

Recently private sector and Lebanese authority built up the Costa Brava landfill in Ouzaai (south of Beirut) to solve the problem of MSW(Obeid, 2016). The new landfill will temporarily solve the problem of the accumulation of solid wastes in the streets of cities but it will not form a permanent and environmentally friendly solution for solid waste. Thus, garbage could start once again piling on the streets if an integrated SWM system is not considered and approved by Lebanese government. Currently, Costa Brava landfill receives around 200 tons of the 650 tons of waste generated per day in the capital. 250 tons of the remaining garbage is sent to a waste treatment plant in Sidon. Outside Beirut and most of Mount Lebanon, dumping of waste and open burning is predominant. Tons of solid wastes are disposed in the environment every year including household waste, bulky items, as well as medical, industrial, agricultural and slaughterhouse wastes.

Treatment of medical waste was principally achieved on-site at hospitals in devoted medical waste facilities. Over time, the expense and regulation of these facilities have prompted organizations to hire contractors to collect, treat, and dispose of medical waste. The proportion of medical organizations that complete their own treatment and

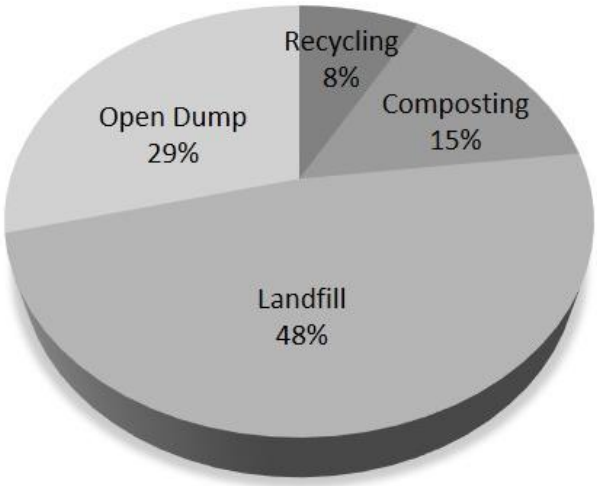

Figure 4: Percent waste recovery and disposal in Lebanon (MOE, 2014).

disposal is expected to drop. Uncontrolled and unlicensed incineration of healthcare waste continues in many hospitals releasing persistent organic pollutants and other pollutants. There are no data for expired medicines in Lebanon. Local authorities (customs, municipalities, regional health councils, etc.) occasionally find stocks of expired medicines and face major difficulties in disposing them. Ministry of Environment has prepared environmental guidelines for destroying expired goods but there are no specialized facilities that can treat the waste. In the absence of such facilities, it can be assumed that expired drugs end up in landfills and/or open dumpsites around the country.

Slaughter houses in Lebanon produces large quantities of different wastes and wastewaters. None of the slaughterhouses currently provide adequate treatment of their waste (blood, internal organs, and bones). On the other hand, wastewater from slaughterhouses is heavy in pollution and it is mixed with the municipal drain system without pre-treatment.

Resource Recovery Methods

Tight budgets and scarce resources have made municipal SWM an environmental, financial, and social burden to the municipalities. Resource recovery from managing MSW has the potential to decrease such burdens and even give profits. The composition of MSW in Lebanon showed organic materials and paper as the dominant factions (Figure 2). Thus, recycling and composting are the most used methods for the recovery of materials from the solid waste stream (Figure 4). The most common materials that are recovered include: organics, various types of paper products, some plastics and metallic containers. The most common methods of recovery are briefly described in the following sections.

i) Recycling

The MSW composition reveals that about 37 % of the waste could be either reused or recycled, excluding organic waste. Unfortunately, only small amount (8 %) was reused and recycled in most municipalities. It is worth noting that minority of Lebanese recover recyclable materials at source and large amounts of recyclable materials continue to be mixed with other types of wastes. Thus it is very difficult to recover recyclable materials of acceptable quality from unsegregated waste stream. When the waste arrives at the two sorting facilities, it is already in a state of decomposition, releasing leachate and foul odors. These undesirable conditions of the wastes encourage recycling industries not to buying them. In addition, there are no specific incentives to promote the recycling industry, in particular technologies that can recycle plastics (PVC and PET) and “dirty” recyclable materials. In this context, plastics, except PET and PVC, are recycled into secondary plastic products such as flowerpots and benches. “Clean” cardboard and paper are recycled by one of the few remaining paper recycling plants currently operating in Lebanon. However, these industrial plants rely mainly on informal networks of suppliers for waste paper and cardboard.

ii) Composting

The high organic content of MSW in Lebanon suggests that composting is the most efficient method to recover the organic materials. Composting provides fertilizers to farmers who otherwise have to buy chemical fertilizers at a high price. It also reduces the volume of the solid waste stream to be handled and disposed of at landfills. Some municipalities have or plan to set up community or municipal composting plants (Table 3). The Coral composting plant uses the windrows system for fermentation (12 windrows, 4-5 m wide and 2.5-3 m high), a trommel screen and a densimetric table for polishing. The composting cycle lasts around 65 to 70 days. All the compost produced are provided, free of charge, to institutions and individuals. Only about 13 % of incoming waste is processed in the Coral compost. The remaining waste fraction is baled, wrapped and hauled for final disposal at the Naameh Landfill (currently at Costa Brava).

Table 3: Municipal composting plants in Lebanon (GIZ, 2010)

Name	Capacity (t/d)	Technology
Coral	300	Windrows
Saida	300	Anaerobic Digestion
Ain Baal	150	Aerated Agitated Bed
Bint Jbeil	20	Aerated Floor
Kherbet Selem	15	Drums
Aytaroun	15	Windrows
Ansar	10	Windrows
Khiyam	10	Windrows
Ain Ebel	10	Windrows
Qabrikha	10	Windrows

Coral composting plant is facing some operational problems such as foul odors from the curing process, space limitation, proximity to residential areas, and mechanical failures. Leachate produced at the plant are treated by anaerobic and aerobic processes. The effluents from this primary treatment are then combined with the bio-filter discharge water and sent by tanker trucks to the Ghadir wastewater treatment plant south of Beirut.

Public Awareness

A critical element in SWM is public awareness, in addition to other factors such as proper legislation, strong technical support, and sufficient funding. Lack of public awareness is one of the major problems of SWM in Lebanon. Only a small percentage of the public know where their own domestic waste goes once it has been collected or how much the waste collection and disposal service costs them. Community participation has a direct effect on efficient SWM plan. Municipalities don't have awareness programs for SWM staff, and for the public. They have failed to educate citizens on the basics of handling waste and appropriate way of storing it in their own bins at the household, shop and other institutions and then disposing it in the communal storage points declared by the authorities. Therefore, the main challenge in SWM lies in alerting the public about not littering and encouraging them to dump the waste at designated points. On the other hand, households, hotels, restaurants, schools and other commercial establishments should be directed to introduce systems for segregation of solid waste. Imposing fine will not give results unless the public understand the importance of keeping the country clean. The essential barriers for raising awareness about waste management activities are:

i. Deficiency in funds and capacity and lack of interest from key stakeholders.
ii. Rooted cultural practices and behavioral norms.
iii. Unsupportive legal and regulatory frameworks.

Special Waste Management

Special waste includes categories of waste slaughterhouses and industry and hazardous waste from hospitals and medical centers. Management of this category of waste is totally different from MSW. Medical waste treatment is usually performed by incineration in hospitals in many municipalities. This involves merely burning of the waste in a chamber or open burning in the hospitals. In other municipalities, medical waste is mixed with municipal waste, and in some cases it is burned or crudely dumped. There is no appropriate system for the management of medical waste, and the staff, including medical personnel, in most hospitals are not aware of the health impacts. On the other hand, no proper slaughterhouse was observed in any of the municipalities. Dead animals are buried or dumped. The burying is done randomly at dump sites.

Drawbacks in Present MSW Services

i. Storage and Collection of Waste at Source

There is no practice of storing the waste at source and citizens have not been cultured to keep domestic, trade, and institutional bins for storage of waste at source and stop littering on the streets. There is no public system of primary collection from the source of waste generation. The waste discharged here and there is later collected by private companies and municipal workers.

ii. Low Percentage of Solid Waste Recovery and High Cost of Waste Treatment

The percentage of recovery of MSW (23 %) is very low in comparison with the amount of wastes disposed in landfills (48 %) and dumped in open areas (29%). All management options adopted across Lebanon revolve around dumping waste either in sanitary landfills or in random sites which would ultimately transform Lebanon into one large dumpsite, at a time when efficient management starts with sorting- at-source and recycling. Illegal dumping exists in Lebanon and all the countries of the region. These are effecting both the environment and citizens in a great degree. Egypt, Palestine, Morocco, Tunisia and Jordan have already set specific targets. In Lebanon, a business plan was prepared in 2011 regarding the rehabilitation and closure of open dumpsites, however no specific target has been set yet (GIZ, 2014). Currently, solid waste is not being treated and all waste is disposed in Costa Brava Landfill which will be closed in four months' time. The cost

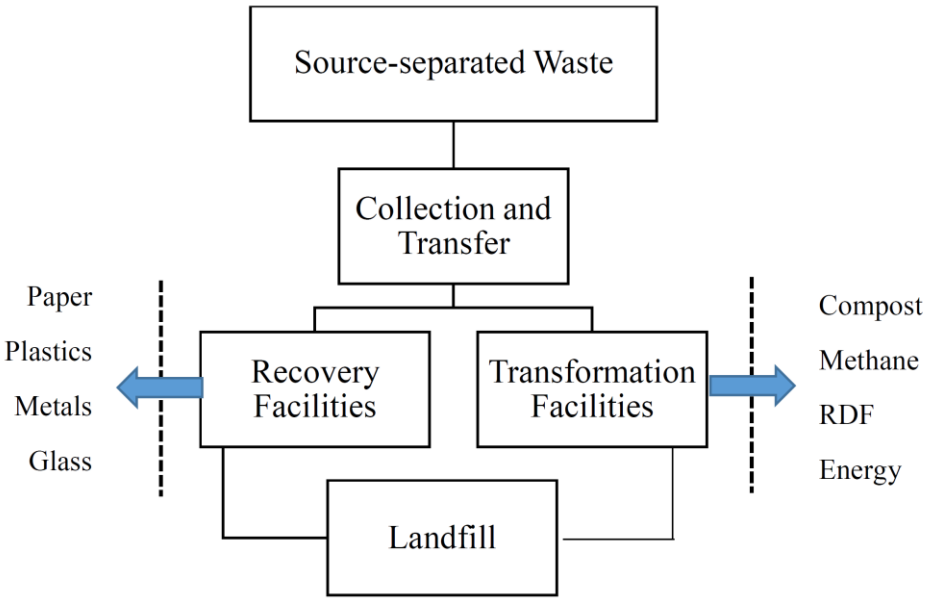

Figure 5: Integrated waste management strategies.

of waste collection and disposal amounts to roughly 120 USD per ton. This high cost prevents municipalities from living up to their responsibilities and leaves them to face wider budget deficits and failure to pay the fees required for collection and treatment.

Key Policy Challenges and Recommendations

i. Since 1994, the government contracted out waste management in Beirut and Mount Lebanon to Sukleen, which continued to collect and manage solid waste by sorting, composting, recycling, and landfilling until the expiry of its contract in July 17, 2015. Since expiry, Lebanon has challenged a garbage management problem. In the absence of governmental solutions, municipalities and citizens used primitive solutions which led to open dumps scattering throughout the country, with serious consequences on health, economy, and the environment. It can be concluded that the development of policy, strategy, and guidelines has not been effective on the ground. A national SWM policy and strategy that specifies key policy objectives, guiding principles, and an implementation strategy needs to be developed to provide clear strategic direction to local bodies. Municipalities are also encouraged to improve their SWM systems. Technical procedures need to be developed for issues such as organic composting, resource recovery technologies, and landfill development and operation.

ii.. The waste in Lebanon represents a significant source of biomass, recycled materials, and energy. The large proportion of reusable and recyclable materials in solid waste offers a great opportunity for improving waste reuse and recycling. Endorsement of 3R policy significantly reduce the amount of waste to be disposed of at landfills, thereby saving costs for final disposal and reducing public health and environmental risks. In addition, based on waste characterization (Figure 2), solid waste could be used as a potential feedstock in various waste to energy technologies such as anaerobic digestion, pyrolysis, incineration, and gasification (Figure 5) (Nizami, 2017). These technologies, if developed in Lebanon, can be able to treat around 80% of the total MSW. The remaining of MSW fraction can be recycled or disposed in landfill. This scenario requires better public awareness of the advantages of these technologies.

iii. Strengthening Capacity of Local Bodies: Municipalities should be in charge of collecting, transporting, treating, and finally disposing MSW. But in Lebanon, most municipalities are facing shortage of financial and human resources, as well as technical skills to effectively manage MSW. Developing the in-house capacity of the municipalities is thus essential. Municipalities that do possess MSW units are suggested to establish one and operate it with suitably qualified individuals. Municipalities should be capable of managing their recycling sites as productive units reducing overall management cost and thus allowing them to give more money for the general well-being of their communities.

iv. Public Awareness and Participation: Lebanon and other countries in the region such as Mauritania and Yemen through their legislation structures and practices, are not encouraging stakeholders to contribute in making waste management more sustainable for their countries. The situation is slightly better in Egypt, Algeria, and Jordan but they have still gaps in their legislative framework (GIZ, 2014). Municipalities alone can't meet the challenge of keeping towns clean and livable. Public involvement needs to be ensured through media, education, NGOs and

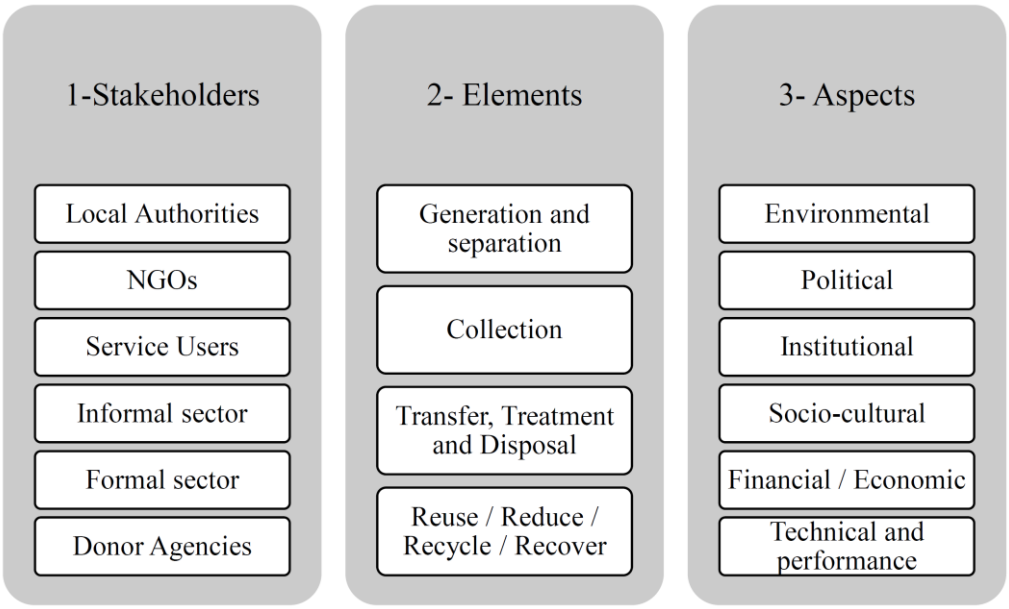

Figure 6: Integrated Sustainable Waste Management Framework (van de Klundert, 2001)

environmental campaigns to improve citizens' awareness of 3R and better SWM. Raising awareness about SWM activities can result in increases in:

a) Use of city waste collection services by the public and private sectors.
b) Implementation and enforcement of local waste management policies and strategies.
c) Backing of municipalities for local-level activities.
d) Segregation at point source and reduction of waste generation.

v. Stop the violation to the Integrated solid waste management (ISWM). Today with the current crisis, a strategy for an ISWM plan must immediately be implemented. There are three dimensions of ISWM, which need to be addressed simultaneously when designing a solid waste management system: stakeholders, elements, and aspects (Figure 6). An integrated approach is necessary from segregation at source and collection to resource recovery and landfill. Sorting garbage at home should be compulsory by the governmental laws. Resource recovery facilities may be built on the way to or near the final disposal sites so that residual wastes from recovery facilities can be brought efficiently for disposal. Recycling paper, plastic, glass, should also be applied and introduced as a law. Smaller municipalities may gradually improve their final disposal method from open dumping to engineered landfill. Incineration can be also considered as an efficient solution due to its high efficiency and low operation cost (1.5-2.5 $/ton) (Ouda, 2016). Nonetheless, the need for treatment of air and decontamination of ashes within the incineration facilities are limiting factors for the development of this technology in Lebanon. Wastes from hospitals, plants, batteries, etc., should be listed as hazardous and submitted to a particular recycling facility or be treated in an environmentally safe manner to prevent land and water pollution.

CONCLUSIONS

The analysis of waste composition revealed that organic content is the highest fraction, making up 52% of municipal waste. Current common practice of SWM in Lebanon is landfilling. After the closure of the main landfill in Naameh, most of solid waste in Beirut and Mount Lebanon is now disposed at Costa Brava Landfill. Most municipalities in Lebanon are unable to manage MSW effectively and efficiently because of the lack of financial, technical and human resources. Government and other stakeholders were unsuccessful to implement an integrated SWM in Lebanon.

The current SWM system in Lebanon has many disadvantages such as: unorganized source reduction programs, high cost of sweeping and collection and low percentage of waste recovery. Several recommendations have been proposed to improve waste management, such as, organizing public awareness programs, which could start from the schools; increasing efforts for recycling, keeping in mind future population growth, resource recovery, strengthening capacity of municipalities and encouraging public private partnerships.

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